Table 4.9 Example of Estimation of Karez Cleaning Work

An example of the data collected during the site survey are shown on Figure XXX. These data have been collected on site and then discussed with the Karez Kan and farmers who have known the karez for a long time and hence its history. From such discussions it is revealed that tunnel six is capped and not collapsed.

1. **Cleaning of Karez**

(a) It is assumed that all of the karez will need to be cleaned of deposited material after blockages have been removed. Available data collected from the site survey are used to estimate the total volume of material to be excavated.

Location	Distance (m) [1]	Tunnel Width (m) [2]	Silt Depth Down-stream (m) [3]	Silt Depth Upstream (m) [4]	Average (m) $[5]=\frac{[3]+[4]}{2}$	Volume of Material to be Removed (m^3) [1]x[2]x[5]
0-1	30	0.65	0.60	0.35	0.48	9.26
1-2	15	0.65	0.35	0.30	0.33	3.17
2-3	16	0.70	0.30	0.25	0.28	3.08
3-8	102	0.70	0.25	0.20	0.23	16.07
Total						31.58
Team Days @ $1.7m^3$						18.6

2. **Cleaning of collapsed well**

(a) It is assumed that when a well collapses, only 3.0 metres of the tunnel will be affected by the material brought down.

(b) Depth of closed or collapsed wells are estimated from available data assuming that there is an average ground slope between the wells and that the contribution of the karez tends to zero, e.g.

depth of well No.3 = 3.9
depth of well No.8 = 9.5

distance between wells 3 & 8 = 102m

average shape between wells 3 & 8 = 5.6/102
= 0.0549

depth of wells = (y x s)+d

where y = distance between wells
s = average slope between wells
d = depth of previous well

Table 4.9 (continued) Example of Estimation of Karez Cleaning Work

Well No.	Distance from Previous Well (y) (m)	Depth of Previous Well (d) (m)	Increase in Depth (yxs) (m)	Estimated Total Well Depth [d+(yxs)] (m)
4	20	3.90	1.10	5.00
5	20	5.00	1.10	6.10
6	22	6.10	1.21	7.31
7	21	7.31	1.15	8.46

(c) material to be excavated.

Well No.	[1] Well Depth (m)	[2] Well(1) Diameter (m)	[3] Cross Sectional area of well (m^2)	[4] Volume of material from shaft (m^3)	[5] Tunnel(1) width (m)	[6] Tunnel(1) depth (m)	[7]=2x3x[5]x[6] Total material from tunnel (m^3)	[8]=[4]+[7] excavation (m^3)
4	5.00	1.00	0.79	3.93	0.70	1.20	5.04	8.97
5	6.10	1.00	0.79	4.79	0.70	1.20	5.04	9.83
6	7.31	1.00	0.79	5.74	0.70	1.20	5.04	10.78
7	8.46	1.00	0.79	6.64	0.70	1.20	5.04	11.68
Total								41.26
Team Days @ 2.75 m^3/team/day								15.0

Notes: (1) assumed from available data

3. **Opening of closed well**

(a) Data on closed wells will be obtained from discussion with the Karez Kan and/or those farmers who know the history of the well, e.g.

depth of well no. 6 (estimated above) = 7.31 metres
depth of cap = 3.50 metres
average diameter of well = 1.00 metres
volume of material for excavation = $(3.50 \times 0.70)m^3$ = $2.77m^3$

An allowance of 15 percent should be included for removal of material entering well when capping is removed.

i.e. extra material = $0.41m^3$

Hence total volume of material to be removed = $3.18m^3$
No. of team days @ $2.75m^3$/team/day = 1.2 days

Table 4.9 (continued) Example of Estimation of Karez Cleaning Work

4. **Additional excavation of material from collapsed or realigned tunnels**

(a) To account for a collapsed tunnel that can only be discovered after the wells have been opened and cleaned, an allowance of 20 percent of the estimated total material excavated from the collapsed wells should be included as a contingency sum, e.g.

contingency allowance $= 0.20 \times 41.26$
$= \underline{8.25}m^3$

Note: For the example given above and considering the allowances for excavation made in the well excavation, this is equivalent to a 70 percent collapse of one tunnel, or 17 percent collapse in each tunnel in the closed and collapsed section of the karez.

(b) If it is assumed that 25 percent of the material to be removed involves excavation in new material, this will be reflected in the reduced output of the team, i.e.

Number of team days for collapsed work $= \frac{(8.25 \times 0.75)}{1.27}$
$= \underline{4.5 \text{ days}}$

Number of team days for re-alignment work $= \frac{8.25 \times 0.25}{1.14}$
$= \underline{1.8 \text{ days}}$

Total team days $= \underline{6.3 \text{ days}}$

5. **Summary of Excavation Requirements**

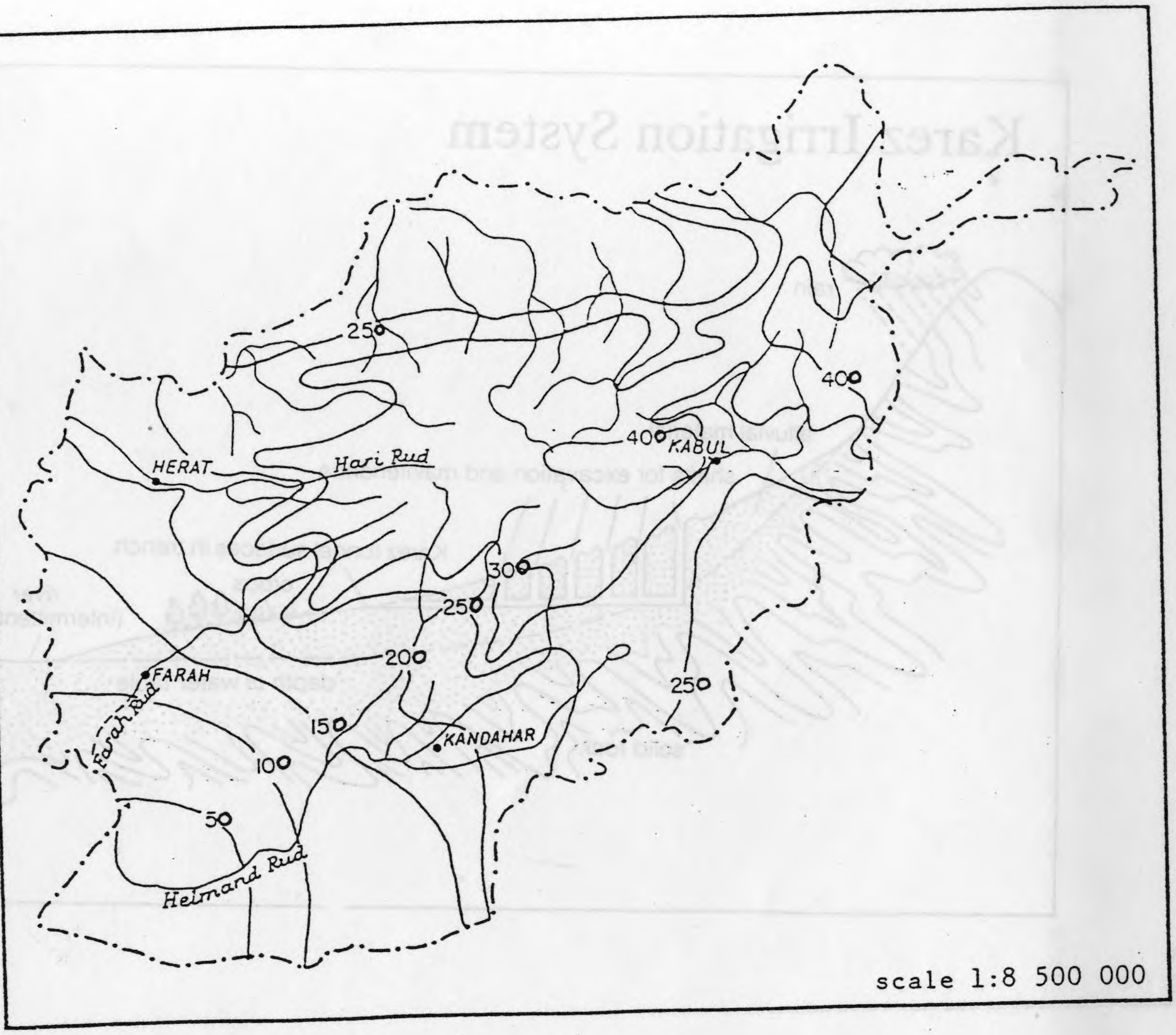
	Work Item	Volume of material (m^3)	Team days (days)	Team output (m^3/day)	No. of workers in team skilled	unskilled
1.	Cleaning of karez	31.58	18.6	1.7	4	0
2.	Cleaning of collapsed well	41.26	15.0	2.75	3	0
3.	Opening of closed well	3.18	1.2	2.75	2	0
4.	Additional allowance for tunnel	8.25	4.5	1.37	4	0
	collapse or re-alignment		1.8	1.14	4	0

7. **Costs of Excavation**

The costs of the excavation work is determined using the team rate for each of the items shown in (6), multiplied by the number of team days.

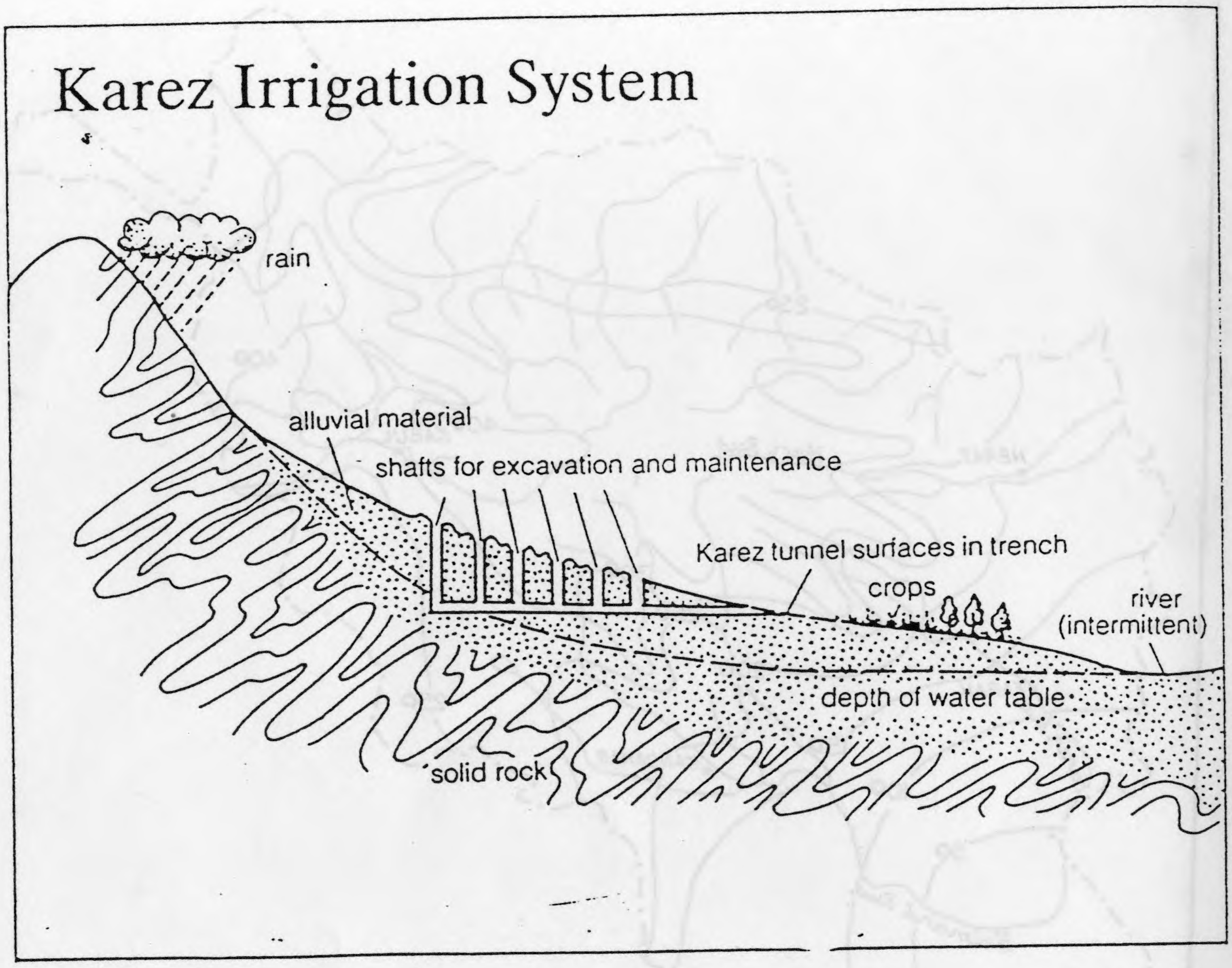
FIGURE 4.1

AVERAGE ANNUAL PRECIPITATION FOR AFGHANISTAN
(mm)



FAO, Land and Water Resource study of Afghanistan, 1965.

FIGURE 4.2
THE KAREZ IRRIGATION SYSTEM



Isobel Shaw, Pakistan Handbook, 1989.

FIGURE 4.3

THE MAIN FEATURES OF THE TYPICAL KAREZ IRRIGATION SYSTEM

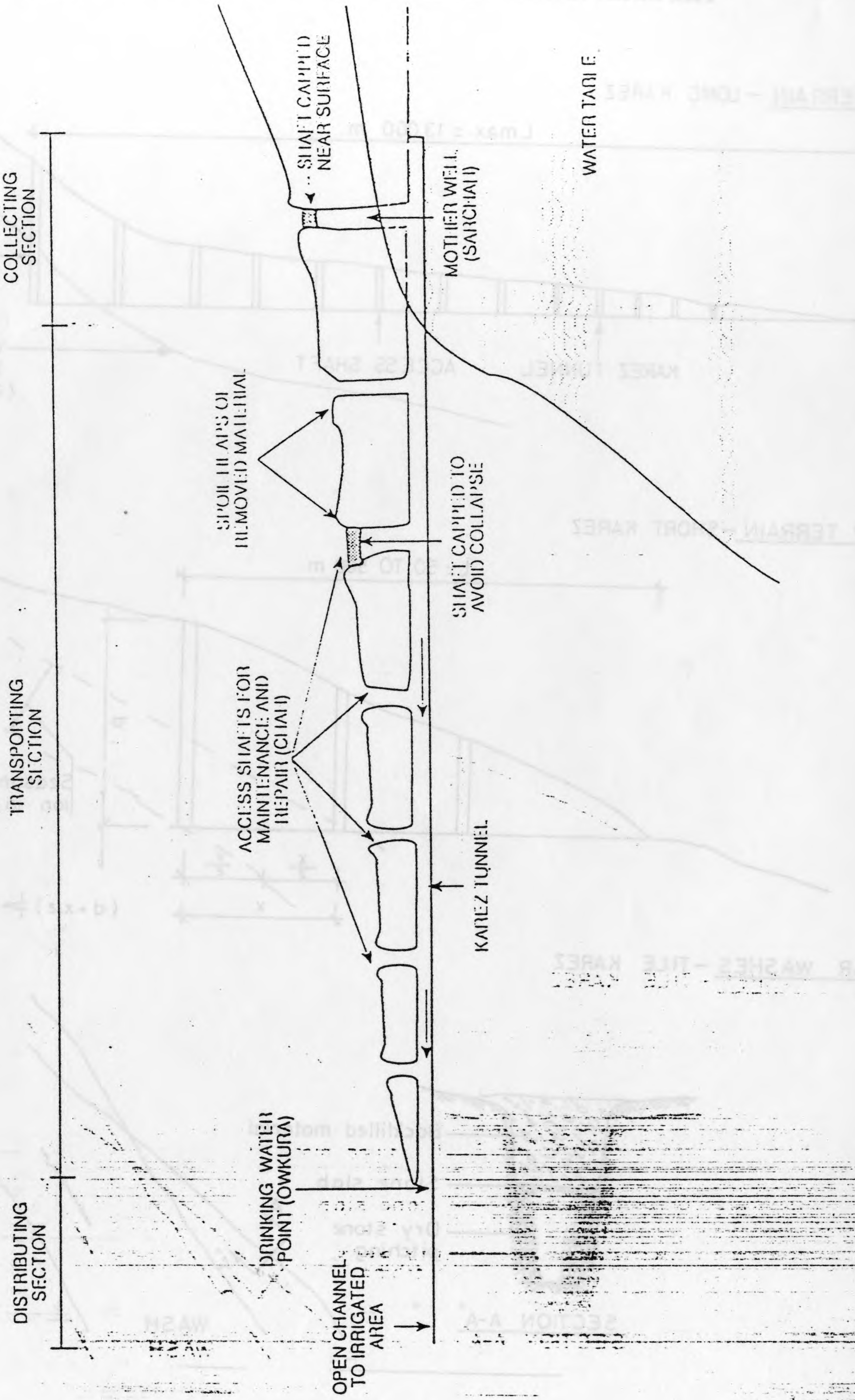
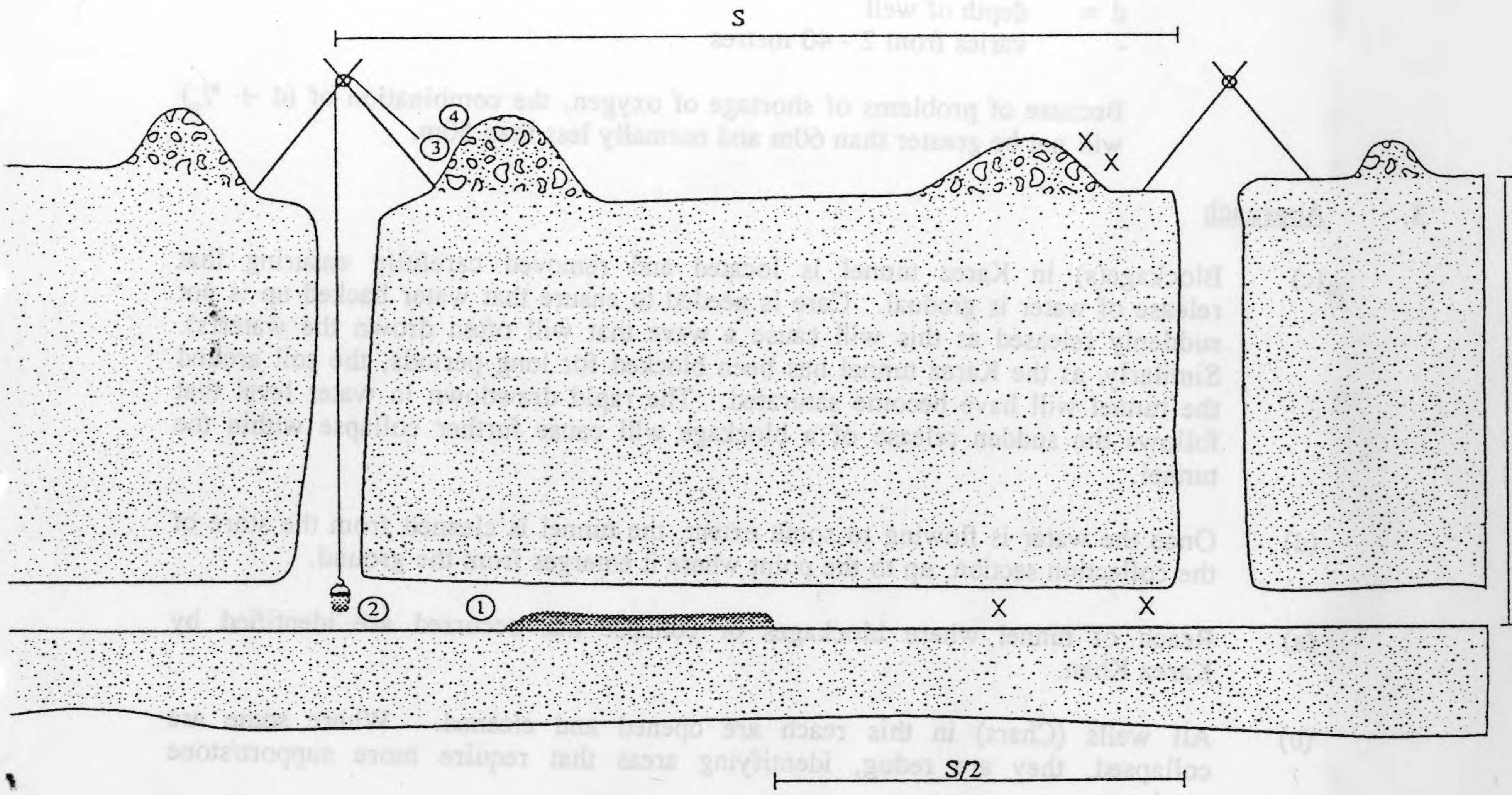


FIGURE 4.5

THE KAREZ CLEANING PROCEDURE



1. Cleaning Procedure

(a) Organisation:

- Team normally consists of four skilled Karez Kans.
- At any one time, two work on the surface, and two in the Karez.
- For the morning and afternoon work sessions, the teams change places.

(b) Jobs:

(1) Uses special pick (one sided) to excavate material and put it into salwagha.
(2) Takes salwagha from (1) and drags into the well shaft, ties it to the rope.
(3) Hauls up the rope on the signal from (2) and gives the salwagha to (4).
(4) Empties salwagha either into wheel barrow or away from well shaft and gives it back to (3).
(3) Ties empty salwagha onto rope and lowers it to (2).
(2) (2) unties empty salwagha and takes it to (1).

Note: At least two salwaghas are always in operation so that (1) does not have to wait.

2. Details

s = spacing between wells (Char)
- varies from 10-38 metres
- normally 20-30 metres

d = depth of well
- varies from 2 - 40 metres

Because of problems of shortage of oxygen, the combination of (d + $^{s}/_{2}$) will not be greater than 60m and normally less than 50m.

3. Approach

(c) Blockage(s) in Karez tunnel is located and removed carefully ensuring that release of water is gradual. Care is needed to ensure that water backed up is not suddenly released as this will cause a wave that will often drown the water(s). Similarly, as the Karez tunnel has been blocked for long periods, the soil around the tunnel will have become saturated. The rapid drawdown in water level that follows the sudden release of a blockage will cause further collapse within the tunnel.

(d) Once the water is flowing to some extent, the tunnel is cleaned from the store of the collection section, up to the point where it emerges from the ground.

(a) Reach of tunnel where blockages or collapse has occurred are identified by Karez Khan.

(b) All wells (Chars) in this reach are opened and cleaned. Where some are collapsed, they are redug, identifying areas that require more support/stone work.

Note: In some cases collapse may be widespread and it may be necessary to re-route the tunnel, excavating a new section.

4. Output

(a) Salwagha capacity

Maximum capacity = $\frac{\Pi}{4} \frac{(d_1^2 + d_2^2)}{2} \times h$

= 0.0285 m^3

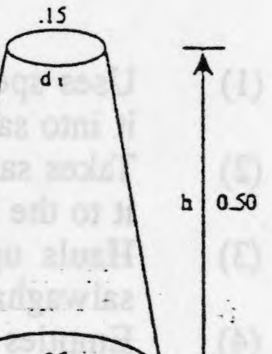
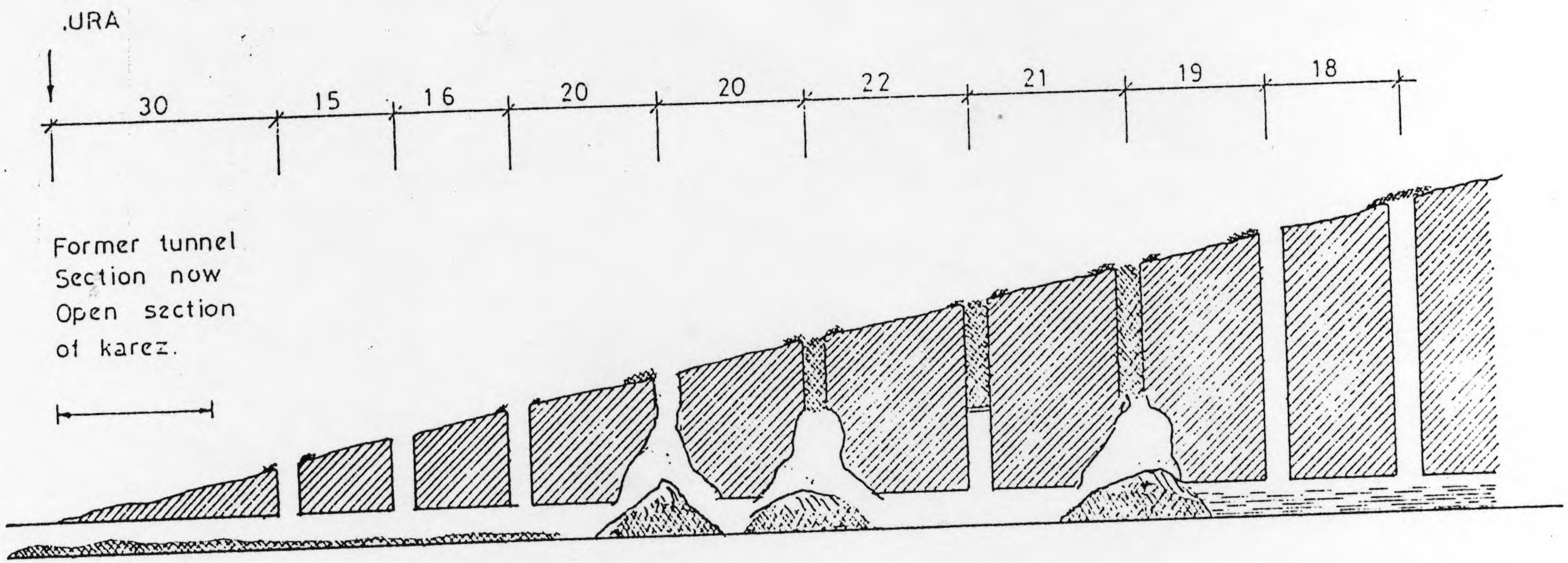


FIGURE 4.6

EXAMPLE OF SITE DATA COLLECTED FOR KAREZ CLEANING WORK



WELL	— NUMBER	1	2	3	4	5	6	7	8	9
CONDATION	— OPEN	✓	✓	✓					✓	
	— CLOSED						✓			✓
	— COLLAPSED				✓	✓		✓		
DEPTH (m)	— SHAFT	2.0	2.8	3.9	—	—	—	—	9.5	—
	— SILT	0.35	0.30	0.25	—	—	—	—	0.20	—
	— WATER				—	—	—	—	0.60	—
APPROX. WELL DIAMETER (m)		1.10	1.05	1.00	—	—	—	—	1.00	—
AP. TUNNEL HEIGHT (m.)		1.20	1.25	1.20	—	—	—	—	1.20	—
AP. TUNNEL WIDTH (m.)		0.65	0.70	0.70	—	—	—	—	0.55	—

5. STRUCTURAL DESIGN

5.1 Introduction

During the year, much time is expended by the farmers on the repair and maintenance of canals. Frequent damage occurs where the canals cross gulleys and washes and in the first reaches of the canals after the diversion weir on the river. Prior to the war, the Rural Development Department was implementing a programme for reducing this time using simple structures that could be replicated everywhere and which were relatively easy to build and maintain. This approach has been continued in the FAO Afghanistan Rehabilitation Programme and the works that have been implemented have concentrated on all of the major crossing points of canals over washes, gulleys etc. and other places in the canal system where farmers have to spend much time in repair and maintenance. The time saved thus enables the farmers to concentrate more on their agricultural activities. In general, because of the inadequate hydrology data and the high flow variation on most of the larger rivers in Afghanistan, it has not been recommended that permanent weirs be provided. Intake structures to protect the canals should be provided, but these should be supplied by local weirs.

Set out below are the main structures that have been considered in the FAO programme and the design approach. Several types of structure have been proposed:

(a) Intakes
(b) Culverts (for gulley and/or track crossings)
(c) Siphons (for gulley and/or track crossings)
(d) Flumes (for gulley crossings)
(e) Division Boxes

In addition to these, certain works for the prevention or erosion (head cutting) in gulleys and the training of river and gulley banks using gabions have also been proposed. The design of these structures are described below. Selection has been made primarily from the ease of construction and maintenance.

Before the design details of each are discussed, a brief discussion is given on the type of structures that should be considered. These are based on the experience gained from the FAO programme:

Diversion Weirs and Intakes

Although at certain times of the year, much time and effort is expended by the farmers in the reconstruction of the weirs at the intakes of the canals, to replace these with more permanent structures, capable of resisting the anticipated flood flows, would be prohibitively expensive. In addition, there is considerable shifting in local bed levels and river alignments, particularly on the Konar river. Permanent structures would preclude the present flexibility in all but a few sites.

(iii) Identify any other larger scale maps that may be available including satellite imagery.

(iv) Examine the activities that were being undertaken before the start of the war/hostilities to determine whether any rural development programmes existed previously and whether any data are still available;

(v) Identify from the available data the main agricultural areas that existed before the war and define the water sources (river; wash; spring; groundwater; karez; well;).

During the course of the mission, the main command areas should be defined and the extent to which each area is currently cultivated assessed. An overview of the irrigation system must be obtained and for each command area, data on the canals that supply them, their approximate location and their water sources should be collected through local discussion and spot checking in the field. Where possible, the canals should be located onto the enlargements of the 1:100,000 scale maps. A flow diagram giving the order and names of the canal systems should be produced (see Table 1.2) for detailed checking during the plan and inventory surveys to be carried out during the stage II.

In order to avoid confusion once work starts, a canal/command area referencing system should be established that lists all canals with their alternative names and their approximate location and their water source (see Appendix 1).

After the completion of the reconnaissance surveys, a clear plan of the work to be undertaken must be prepared together with outline costs to ensure that sufficient funds are allocated to meet identified components. This plan should identify firstly the immediate work that can be carried out and secondly the additional assistance that could be provided once more detailed information has been collected. As soon as the more detailed survey data are received from the field, the outline costs can be checked and refined. The full details cannot be defined until the initial surveys have been completed, but experience gained from the FAO Kunar and Eastern Paktia programmes can be utilized. These have be used to produce typical costs curves presented in chapter 6. To these should be added the costs of the surveys as well as contingencies and supervision. General planning costs are given below.

Farmers overcome the considerable variation in river stage from wet to dry season, by adopting two intake sites, one the "winter" intake, one the "summer" intake. The former can be several hundred metres upstream of the latter, but still guiding the water to the same stable section of canal. Improvements to the irrigation systems have thus been considered downstream from the diversion weir only, where the stable channel section leaves the main course of the River.

Intake Structures

Very few of the existing canals have any means of keeping the flood waters out from the canals or for closing the canals for maintenance. To overcome the possibility of damage during times of high river flow, "breach" sections of canal are provided that preferentially break as the flood waters increase. This still renders the canals liable to flood damage and silt accumulation. For all canals, intake structures that can be fitted with stop logs are proposed. Although some of the flood waters will be able to enter the canal if the stop logs are not fitted, the structure will act as an orifice control, limiting the amount of water that enters under the flood conditions to the full capacity of the downstream canal including freeboard.

Wash and Gulley Crossings

From field examination of existing structures Konar, it was evident that structures that were designed with submerged inlets did not perform satisfactorily, either silting up or becoming blocked with debris. Where possible therefore, free flow culverts have been proposed for the crossings of gulleys and washes. To achieve this the canals require realignment upslope using the minimum radius of curvature indicated in Chapter 3. As the slope of the washes is quite high (2-5 percent on average), the distance that the canal will have to be moved is not great. Where additional considerable lengths of canal are required, alternative structures such as Siphons or Flumes will have to be considered depending upon the site.

Most washes are accumulating in level except where they approach the course of the Konar river. The designs for the culverts have therefore assumed that the top of the slabs will be between 0.25 - 0.50 metres below the level of the wash at the crossing point. Each site will have to be examined carefully to ensure that head cutting is not taking place. This will be revealed if longitudinal sections of the wash or gulley are taken. Where it is considered that the level of the wash or gulley is reducing, allowance should be made in the design either by lowering the soffit of the structure or providing gabion protection against damage.

Bank Protection Works

During the flood season, the rivers continually erode their banks and adjust the alignment of their course. Some of these result in damage to the canals, particularly in the reaches just downstream from their intakes. Gabion protection of the banks of the river is required in such cases and these should

extend sufficiently upstream and downstream to ensure that the protection works are not by-passed. Each site will have to be examined for its particular requirements.

Similar approaches should be used for the protection of gulley banks and care must be taken to ensure that the structure provided extends at least one basket depth (1.00 metres) below the anticipated future bed level of the gulley or river at the protection point. As a general rule this level will be a minium of 2.00 metres below current bed level.

5.2 Design Consideration

(a) Construction Materials

Availability of construction materials and ease of construction in comparatively remote areas are important considerations when designing structures. Masonry, and especially stone masonry, have been used in Afghanistan for many years for the construction of irrigation and drainage structures. The material has the advantage that it is cheaper that concrete alternatives, under most situations, it is durable, and the local skilled labour are used to its construction. Recent rehabilitation works have used both masonry and concrete works or a combination of the two, and the local engineers are familiar with the use of both. As the greatest requirement is for structures that can cross gulleys, a combination of masonry walls with reinforced concrete slabs has been used.

(b) Masonry Walls

In many of the agricultural areas where structures are required, the soils are a mixture of silty to medium/coarse material. The angle of internal friction for these soils can be considered to vary from 30 to 40 degrees with an average value of 35. From stability considerations, the ratio of bottom width of a masonry retaining wall to the retained height, with a safety factor of 1.5, can be expressed as below:

Angle of Internal Friction	b/h
30	0.52
35	0.47
40	0.42

For the design of the irrigation structures, where heights of retained material are not excessive and also the likelihood of saturated conditions in the soils retained is low (provided that weep holes are provided), a minimum value of b/h of 0.52 has been adopted.

(c) Reinforced Concrete Slabs

The construction period available for many of the irrigation structures proposed is limited due to the intensity of cropping pattern and the multiple use to which the canals are put. To increase both the quality of the concrete works and also the rate of construction, prefabricated units for conduit covers have been recommended. These have been designed so that they can be lifted by one to four labourers and will be simply supported on masonry walls. Steel mesh fabric reinforcement has been proposed as this also reduces the time and experience required for steel fixing.

```
             |<-------------- L --------------------->|

    -------------------------------------------------------
             |                                        | |
             |        Precast Concrete Slab           | d
             |                                        | |
         -----------------------------------------  -
                  |                                        |
             |< x >|<----------- W -------------->|< x >|
                  |                                          |
    Masonry |             Conduit Passage      | Masonry
     Wall      |                                | Wall
```

All slabs are 0.50 metres long irrespective of the span and the details and weights are given in Figure 5.1. together with typical steel arrangements for different loading conditions. It should be noted that where local slate or flat stones are available, these can be used as conduit covers for spans of less than 0.8 metres.

(d) Transitions

A channel transition can be defined as a local change in cross section that produces a variation in flow from one uniform state to another. In many hydraulic structures, the main reason for constricting or fluming the flow at the inlet is to reduce the costs of construction of the structure. It is important that transitions to and from structures are properly designed when head losses are critical. Transitions can serve several other functions:

- Minimize canal erosion
- Increase the seepage path
- Retain earthfill at the ends of structures

In Figure 5.2 the various types of transition structure that are available are shown. Although some of the designs have a low value of loss coefficient, they are difficult to construct and can often be very time consuming if the site staff are not familiar with them. Considering the experience within the Konar basin, the straight line walls have been proposed for both inlet and outlet works. For these standard transitions, the head loss coefficients for both inlets and outlets are obtained from Figure 5.2 and can be summarised:

Type of Conduit	Inlet	Outlet
Rectangular Conduit (free flow)	0.50	1.00
Rectangular Conduit (submerged flow)	0.55	1.10
Pipe Conduit	0.55	1.10

The computation of losses across the structures are discussed in the relevant sections below. In general for box sections, the bed width of the structure and that on the canal should be kept the same with the floor of the box section and depressed if sufficient area of flow is not available. In such a case, if the levels were made the same, then the upstream depth of flow would need to be increased in order to pass the discharge through without contraction and this could endanger the upstream section of the canal.

If additional lengths of transition are not required to increase the seepage length (see section (e) below), then the lengths of the transitions should be as follows:

Length of inlet transition = 2 x h x m
Length of outlet transition = 4 x h x m

where:

h = depth of flow
m = side slope of canal

(e) Seepage and Uplift Pressures

Irrigation structures, especially in unlined canals and on permeable foundations, can be subject to under seepage and uplift pressures that can undermine the stability of the structure and foundation with the subsequent collapse. For most of the structures that will be built on the irrigation systems, this should not be a major problem but should be analyzed particularly at structures near to washes and along steep slopes. For these conditions, the **Lane's Weighted Creep Theory** is a convenient method for estimating the seepage and uplift pressures.

The method is based on the theory that the seepage path beneath a structure is composed of the sum of all vertical surfaces and those steeper than 45 Degrees plus one third of all the remaining surfaces. The weighted creep length (Lw) is then given by:

$$Lw = 1/3\,N + V$$

where:

N = the sum of all the horizontal contacts and all sloping contacts less than 45 degrees

V = the sum of all the vertical contacts and all sloping contacts greater than 45 degrees

To ensure safety against piping, the following must hold:

$$Lw > C\,H$$

Where:

H = seepage pressure head
= difference between upstream and downstream water levels

C = Safe Weighted Creep-Ratio which is an empirical coefficient depending upon the nature of the soil. Typical values for C are given in the table below:

Material	C
Very fine sand or silt	8.5
Fine sand	7.0
Coarse sand	5.0
Gravel and sand	3.5-3.0
Boulders, gravel and sand	2.5-3.0
Clayey Soils - soft	3.0
Clayey Soils - medium	2.0
Clayey Soils - hard	1.8

The residual uplift pressure (H_t) is given by:

$$H_t = H\,(1 - \text{Creep length/total creep length})$$
$$= H\,(1 - L/Lw)$$

The thickness of floor (T) to counteract this is given by:

$$T = H_1 / (G - 1)$$

where:

G	=	Specific gravity of the floor
	=	2.4 for concrete
	=	2.2 for masonry

Most seepage problems are shown and treated in a two dimensional analysis. However downstream cutoffs should be extended far enough laterally to ensure that there is not a shorter seepage path along the sides of the structure which will cause piping.

(f) Head Loss

The head loss across each structure must be determined considering the hydraulic conditions at each site. For general planning purposes, it is however helpful to give an indication of the minimum head loss that can be expected for each type of structure. These are given in the table below:

Type of Structure	Approximate Minimum Head Loss (m)
Cross Regulator	0.10
Check	0.10
Aqueduct	0.10
Culvert	0.15
Siphon	0.20
Support Piers	0.08
Screens	0.05

5.3 Structures

(g) Culverts

A culvert is used to convey an irrigation canal beneath another water course (wash), drain or road. Flow within the culvert should be sub-critical but, to limit the cost of construction materials, the

velocity in the structure should be greater than either the upstream or downstream canal reaches. The following criteria should be considered in the design :

(i) For efficient designs, the culvert should be submerged both at the inlet and the outlet. From other considerations such as floating debris, cleaning etc., an open channel with free flow, designed for unsubmerged conditions is more suitable. The latter is preferred although in some cases this may increase the costs to unacceptable levels;

(ii) For design purposes the velocities in the culverts are taken as 1.5 m/s. To avoid standing waves at the water surface and to avoid the turbulent flow that occurs when approaching critical flow, the Froude Number of the accelerated flow should not exceed 0.5. i.e.

$$F = Va / (g.A/B)^{0.5} < 0.5$$

Where:

F	=	Froude number
Va	=	Average velocity in structure (m/s)
g	=	Acceleration of gravity
	=	9.8 m/s^2
A	=	Area of flow in m^2
B	=	Open water surface width (m)

(iii) Where concrete pipes are used, minimum pipe diameters should be 0.60 m to permit access for cleaning and to reduce the likelihood of blockage;

(iv) For diameter of pipe [D] less than 0.60 m unreinforced concrete pipes are used and for D larger than 0.60 m either reinforced concrete pipe or pipes with additional masonry works should be used;

(v) Cover on all pipe culverts under a road or embankment which carry vehicle loads should be at least equal to the pipe diameter or a minimum of 0.60 m;

(vi) Three types of culvert have been considered:

- Unreinforced Concrete Pipe
- Reinforced Concrete Pipe
- Rectangular conduits constructed from stone masonry with a reinforced concrete slab as cover;

(vii) The value of Strickler's roughness coefficient adopted are:

Concrete	70
Stone Masonry (plastered)	65
Stone Masonry (unplastered)	60

Short Culverts

Short culverts are defined as those whose length is less than 20 metres. For culverts flowing full, the head loss is given by:

$$Q = u\ A\ (2gz)^{1/2}$$

where:

Q	=	Discharge [m3/s]
u	=	Discharge coefficient (see below)
A	=	Area of pipe [m2]
g	=	Acceleration due to gravity [m/s^2]
z	=	Head loss over the culvert [m].

Values of u for Short Culverts

Bed Level at Structure Same as in Canal		Bed Level at Structure Higher than in Canal		
Sides	u	Sill	Sides	u
Rectangular	0.80	Rectangular	Rectangular	0.72
Rounded	0.90	Rounded	Rectangular	0.76
		Rounded	Rounded	0.85

Long Culverts

For culverts longer than 20 m, entrance, exit and friction losses need to be considered:

(i) Entrance and exit losses

For transitions in open channels where the Froude number does not exceed 0.5, the energy loss at the inlet (H_{inlet}) and outlet to/from the culvert is given by:

$$H_{inlet} = y_{inlet} (Va-V_1)^2/2g$$

$$H_{outlet} = y_{outlet} (Va-V_2)^2/2g$$

Where:

y_{inlet} = Head loss coefficient at the inlet given in Figure 5.2
y_{outlet} = Head loss coefficient at the outlet given in Figure 5.2
Va = Accelerated average velocity in the conveyance structure

V = Average velocity in either the Upstream (V_1) or downstream (V_2) channel [m/s]

(ii) Friction Losses

The energy loss due to friction can be calculated from the following equation:

$$H_f = C_f V^2/2g = V^{2L}/C^2R$$

Where:

C = $kR^{1/6}$ [k = Strickler's roughness coefficient (k = 1/n = 70 for concrete)
R = Hydraulic radius [m]
L = Length of conduit [m]
V = Velocity in conduit [m/s]

In Figures 5.4 to 5.6, typical culvert structures that have been used in the FAO programme are shown. These have been used to cross washes of different widths and slopes and have been preferred to the syphon alternative (see (b) below).

(b) Syphon

A syphon is a structure which conveys a water course (usually a canal) underneath another water course, drain or a road. In most cases these are not recommended as they are difficult for the farmer to maintain and they can easily become blocked if not maintained. If they are to be used, the following design criteria should be considered:

(i) In an inverted syphon water flows under pressure;
(ii) The minimum diameter to permit access for inspection and cleaning and to prevent blockage should be 0.70 m;

(iii) To guard against clogging of the syphon barrel and to protect against involuntary entrance by people or animals it should be closed off with a trashrack;

(iv) A side-spillway is provided just upstream from the syphon to protect the upstream canal against overtopping of its banks if the syphon gets blocked and to permit diversion of flow away from the syphon during maintenance;

(v) Allowable velocity in an inverted syphon should be at least twice the normal canal velocity and should not be less than 1 m/s. The maximum velocity should not exceed 3 m/s;

(vi) The hydraulic design calculation for syphon structures is similar to that for a long culvert. The entry, exit and friction losses must be considered and in addition losses in the bends or elbows (sharp changes in direction) should also be determined.

(vii) A sediment collector should be provided upstream of the syphon to prevent wash material and some sediment transport entering the syphon.

(viii) Man holes should be avoided except where the barrel is long (greater than 30 metres). Where these are provided, the height must be above flood level and the hydraulic grade line, the tops must be well sealed, and the covers suitably designed to ensure that they are not easily removed, but can still be taken off for maintenance.

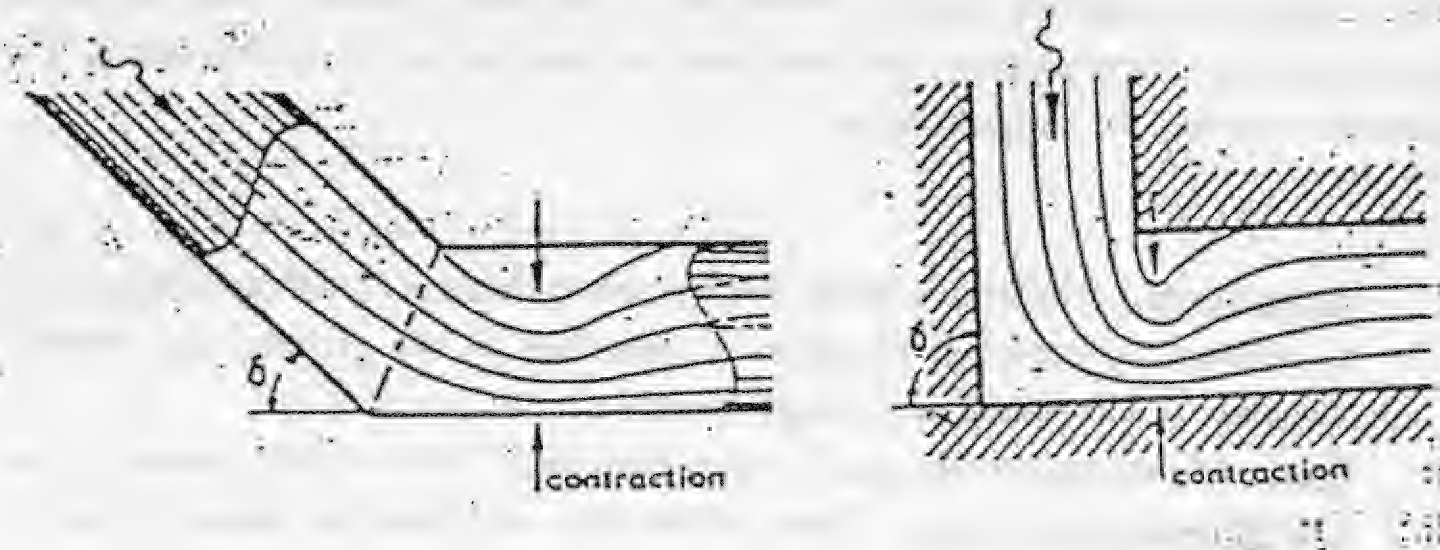
Elbows and bends cause a change in the direction of flow and consequently a change in the general velocity distribution. The resultant changes in pressure and separation of flow causes additional head losses that can be expressed as:

$$h_b = K_b.(Va^2 / 2.g)$$

Where:

h_b	=	head loss in the elbow or bend
Va	=	Velocity of flow
K_b	=	Energy coefficient (see table below)

Losses in syphons with rectangular profiles are somewhat higher than for a circular profile due to the less favourable velocity distribution and consequently additional turbulence:



Description Item	Estimated Cost (US$/ha)
Preliminary Surveys	2
Initial Cleaning Works	10
Detailed Cleaning Works	12
Detailed site surveys	5
Structural Works	50

It should be noted that costs for the supporting or additional technical staff, other than those directly supervising the field works, must be shown and costed separately.

1.4. Stage II - Initial Field Surveys

Different types of survey data are required to define the needs of the identified area and the priorities for support. These are divided into three types of survey:

(a) Canal plan surveys,
(b) Canal inventory surveys,
(c) Canal topographical surveys,

1.4.1. Plan Surveys

These surveys are carried out to define the canals within the command areas and also to confirm the draft layouts that have been prepared during the initial field reconnaissance surveys. These layouts and canal flow diagram should be checked together with available topographical maps to define the location, length (main or important branches), water source and command areas of each canal and to confirm its current condition and whether any external assistance has already been provided.

Using these data, a draft priority list of canals for immediate cleaning and other assistance and a recommended order for further survey should derive.

1.4.2. Immediate cleaning

As soon as possible after the plan surveys have identified canals for immediate cleaning, and if possible within one month of the initial reconnaissance mission, agreements should be signed for the first cleaning work. This will concentrate only on those canals that have not received any assistance

Typical Values for K_b for Different Angles and Profiles

Profile	Angle (Degrees)								
	5	10	15	22.5	30	45	60	75	90
Circular	.02	.03	.04	.05	.11	.24	.47	.80	1.10
Rectangular	.02	.04	.05	.06	.14	.30	.60	1.00	1.40

(vii) Where trashracks are provided, the head loss through the trashrack is calculated with:

$$hf = c.v^2 / 2g,$$

and

$$c = (s/b)^{4/3}.\sin <$$

Where:

hf	=	head-loss (m)
v	=	velocity through rack (m/s)
g	=	Acceleration of gravity (m^2/s)
c	=	Coefficient based on:
y	=	shape factor (2.4 for rectangular, and 1.8 for round bar)
s	=	thickness of bars (m)
b	=	clear distance between bars (m)
<	=	angle of inclination from horizontal

(viii) Inverted syphons with a length of over 100 m must be fitted with manhole and drainage gates, if the situation allows.

(c) <u>Flumes</u>

Flumes are used to convey canal water along steep hillside terrain, or to convey canal flumes supported on a bench excavated into a hillside which are called bench flumes. Flumes supported above the ground with reinforced concrete, structural steel, or timber are called elevated flumes. The following features were used for design criteria:

(i) **Foundations.** Trestles or columns resting on strip footings at sufficient depth not to be affected by scouring, irrigation or ploughing in the vicinity, are normally adequate. In soft ground piles should be used.

(ii) **Span.** The most economic span for simply supported flume sections is about 5-7 m.

(iii) **Reinforcement and Cover.** Steel welded fabric reinforcement should be used to

resist lateral bending moments and provide nominal longitudinal steel of at least 0.22 percent by area. A minimum cover of concrete over reinforcing steel of 10 mm. should be adopted.

(iv) **Freeboard.** For flumes of capacity up to 300 l/s the minimum freeboard is 0.15 m. For flumes of a larger capacity the minimum freeboard is 0.20 m.

(v) **Flow Conditions.** Channel slope is normally in the range 0.0002 to 0.0003, and flow is sub-critical. If steeper slopes are necessary, the Froude number should be kept below 0.6 with a Manning's n of 0.010.

In most cases it has been found that reinforced concrete flumes supported by masonry walls are the most appropriate structures. An example of a typical structure is given in Figure 5.7.

(d) Drop Structures

Drop structure will be needed where the natural terrain slope is steeper than the maximum permissible canal slope to avoid erosion in earth canals. A drop structure has four functional parts, each having its own typical design features:

(i) the part upstream of the control section, being that section where flow becomes super-critical;
(ii) the part in which water is conveyed to the lower elevation;
(iii) the part immediately downstream of the U section, where energy is actually dissipated;
(iv) the channel reach requiring protection against erosion.

The following criteria should be used for design:

(i) For drop heights of 1.5 m or less, vertical drops should be adopted. Where the drops have to be greater than 1.5 m, inclined drops should be used.
(ii) With a vertical drop, the free falling nappe will strike the basin floor and turn downstream at section U (see diagram below). Some energy is dissipated upstream of U.

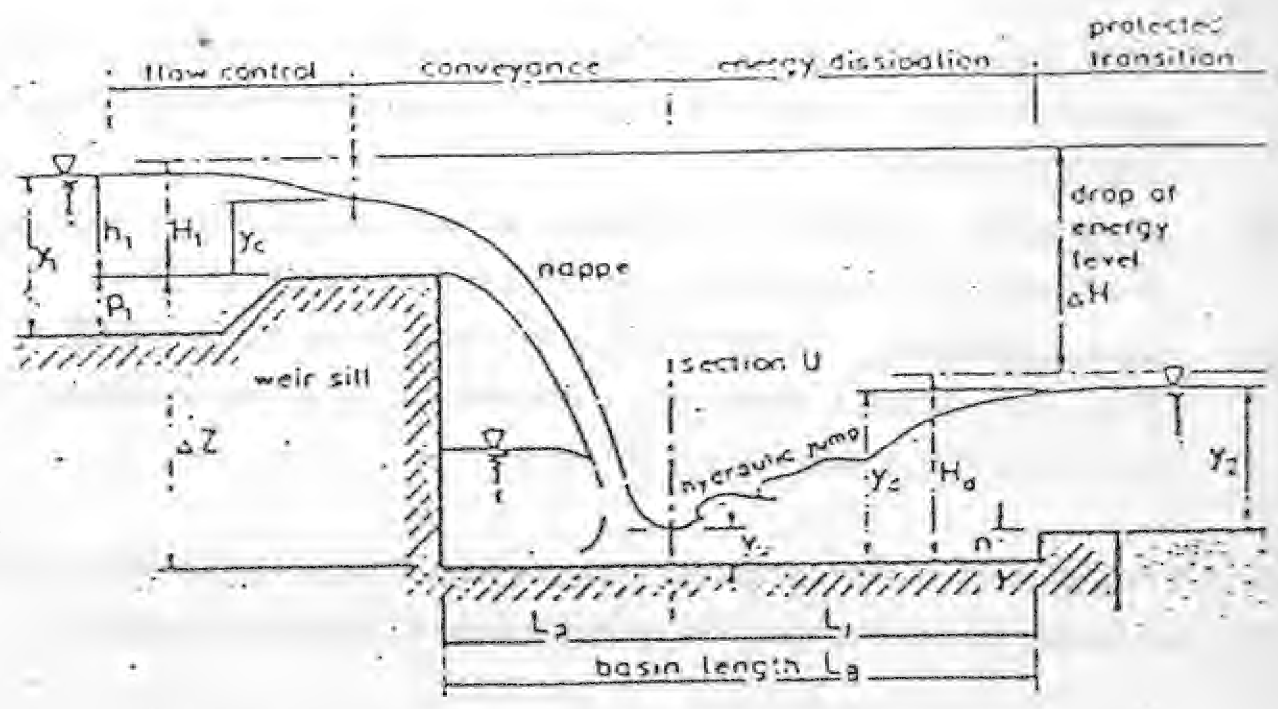


Illustration of terminology on an energy dissipation structure

(iii) The remaining downstream basin-bottom-referenced energy head Hd of a vertical drop does not vary greatly with the ratio ^z/H1, and is about equal to 1.67 H1.

(iv) Determination of the drop height can be estimated by the following equation:

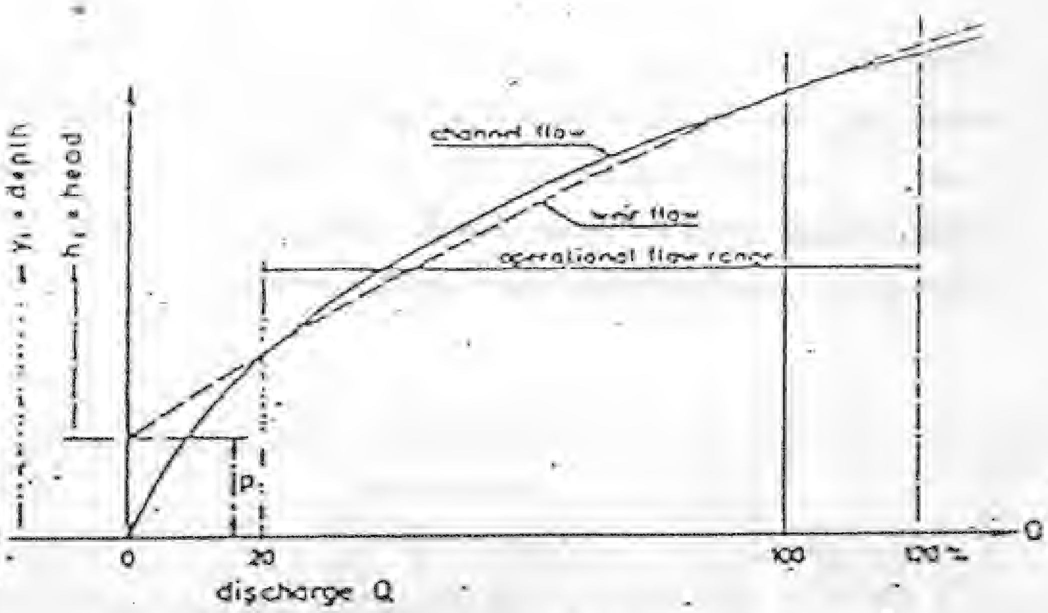
$$\hat{z} = (H + Hd) - H1$$

where:

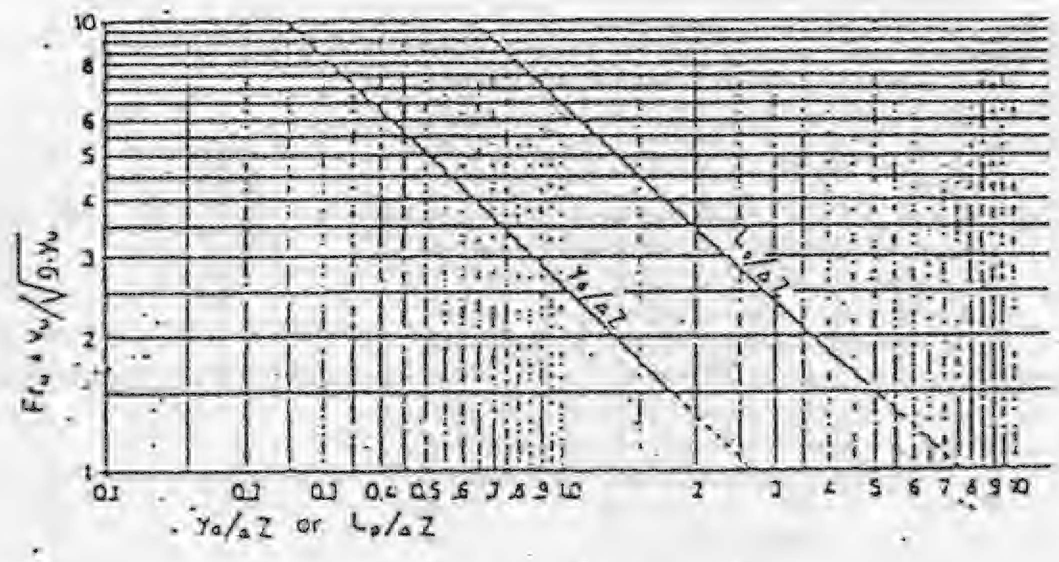
^z	=	drop height in m
H	=	change of head over structure in m
Hd	=	downstream basin-referenced energy head in m

(v) Upon determination of a control section, the Q versus h1 curve can be plotted on a graph. On this same graph a plot should be given of the discharge versus water depth of the upstream channel as shown below. By varying the control values both curves can be made to match over the common range of flows in the channel. The advantage of this matching is that the control does not cause a backwater curve (and sedimentation) nor a water surface drawdown (and erosion) in the upstream channel.

(vi) The vertical drop geometry, through the ratios yd/^z and Lp/^z can be calculated from the figure below:



Matching of the $Q - y_1$ and $Q - h_1$ curves of a structure



Dimensionless plot of straight drop geometry

(e) Division Structure

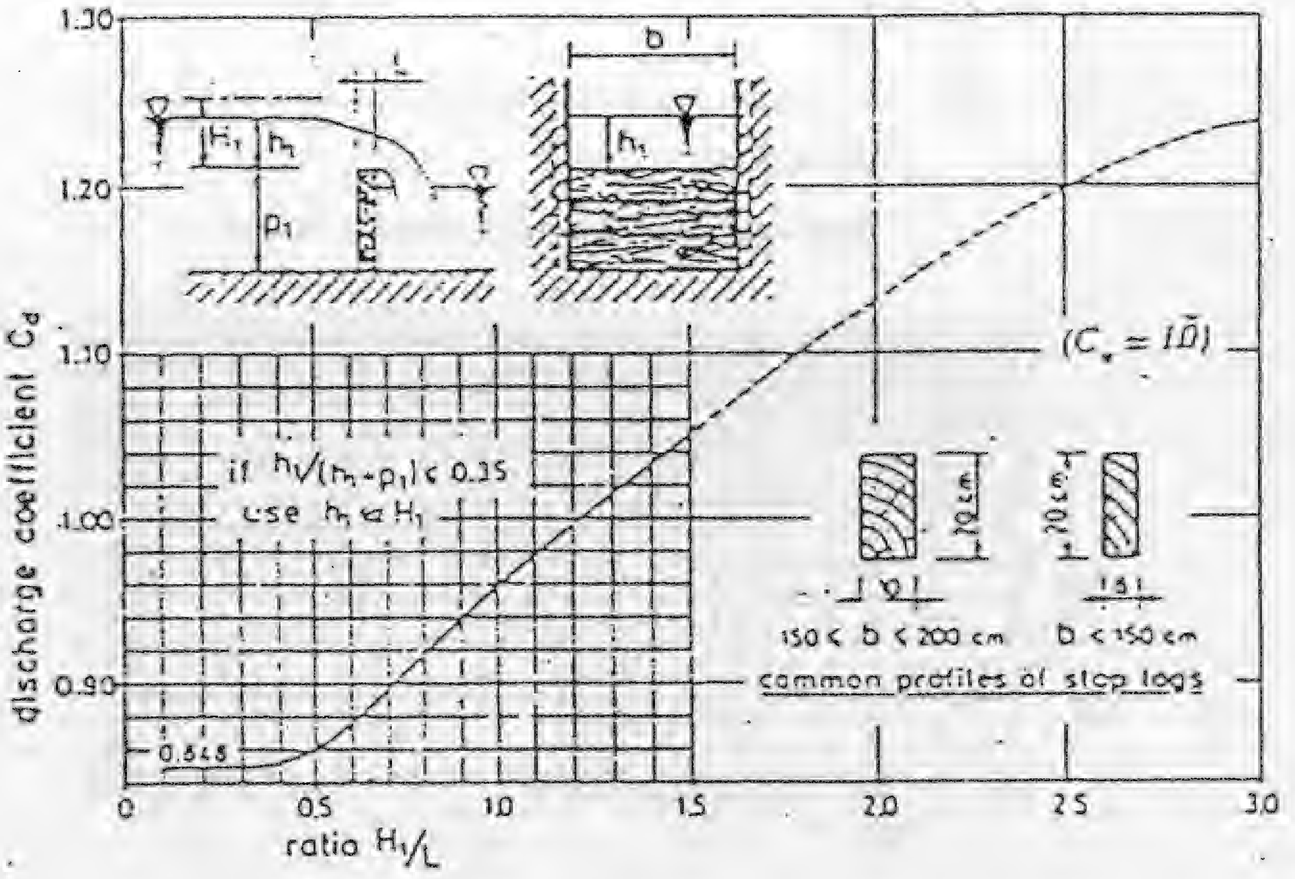
Where in an irrigation system water is divided between two canals, a division structure is constructed. The simpler type of structure comprises two rectangular openings that are dimensioned according to the flow that is required in the downstream canal. With no stop log fitted, the width can be determined using the broad crested weir formula for each with a constant value of head "h". The following aspects should be considered:

(i) For contour primary canals the head loss must be as small as possible: 5 to 10 cm and therefore the check structures in the primary canals will be wide.

(ii) To reduce the head loss, but also to prevent scouring it is recommended to limit the velocities in the check structure to about 1.5 m/s.

(iii) The check structures in canals where head loss must be minimized should be designed without a crest. Sediment can then pass unhindered and the head loss is minimal.

(iv) There are three simple ways of regulating water level namely (i) stoplogs with undershot gate, (ii) fixed crest with undershot gate and (iii) fixed crest with stoplogs. From a construction point of view the stoplog gate is a more simple device. The Figure below shows the discharge coefficient for flow over rectangular profile stoplogs including common profiles of stop logs.



(v) Flow over the stop-logs can be estimated by use of the formula:

$$Q = Cd \times Cv \times 2/3 \ (2/3g)^{0.5} \ bh^{1.5}$$

where:

Q	=	discharge in m3/s
Cd	=	discharge coefficient
Cv	=	approach velocity coefficient
g	=	acceleration of gravity in m/s2 (9.8)
b	=	width of over-fall in m
h1	=	water depth over the stop-log in m

(vi) The discharge coefficient Cd, for a rectangular profile with sharp 90-degree upstream edge, is shown for H1/L ratios below 1.5 (see Figure above).

(vii) If $h1/(h1+p1) < 0.35$ the error made by neglecting the value of the velocity head is small with respect to the error in Cd.

(viii) The common profiles of stop logs are shown in the Figure above. The following thicknesses should be used as a guideline:

150 < b < 200 cm to use stoplog thickness of 10 cm, and b < 150 cm to use stoplog thickness of 6 cm.

(ix) The upstream water elevation can be regulated by placing or removing one or more stoplogs, this step by step regulation is influenced by the height of one stoplog. A suitable height for logs in irrigation canal structures is 0.2 m.

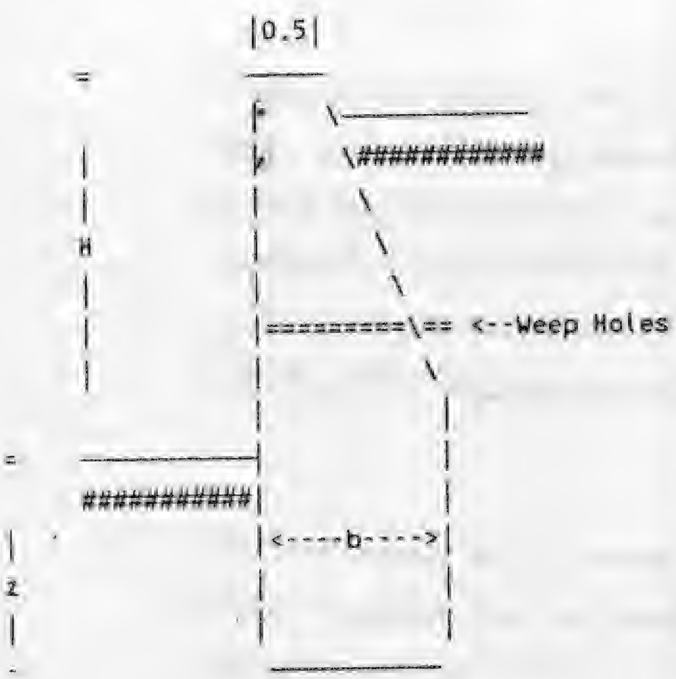
(x) Grooves are 0.03 m to 0.05 m wider than the thickness of the logs, with a width of the control openings of 2.0 m or less.

(f) Erosion Control Structures

For all structures masonry walls have been used except for river and gulley training works where gabion baskets have been adopted. On a few of the gulleys/washes, head-cutting is taking place. This has resulted in the case of the Khas Konar canal of a drop of nearly 3 metres across the canal. Before a permanent crossing is considered for the canal, means of controlling this head-cutting is required. Gabion basket structures provide a cost-effective solution. The structure should be designed as a weir, with the length of downstream protection determined from the hydraulic requirements of the stilling basin.

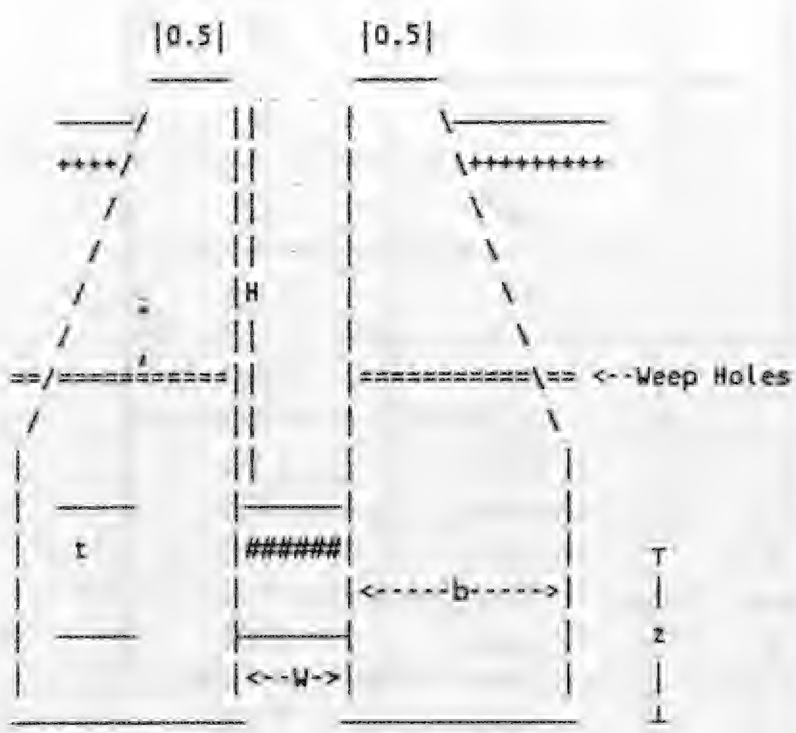
No data on rainfall intensities and runoff are available and thus estimates of the capacity of the wash/gulley should be made considering both its existing shape and slope and also standard runoff formulae. For the Khyber wash across the Khas Konar canal, a flood flow of 15 m³/sec was estimated and the structure that derived is shown in Figure 5.8.

TABLE 5.1 HEIGHT OF MASONRY WALLS FOR RURAL IRRIGATION STRUCTURES



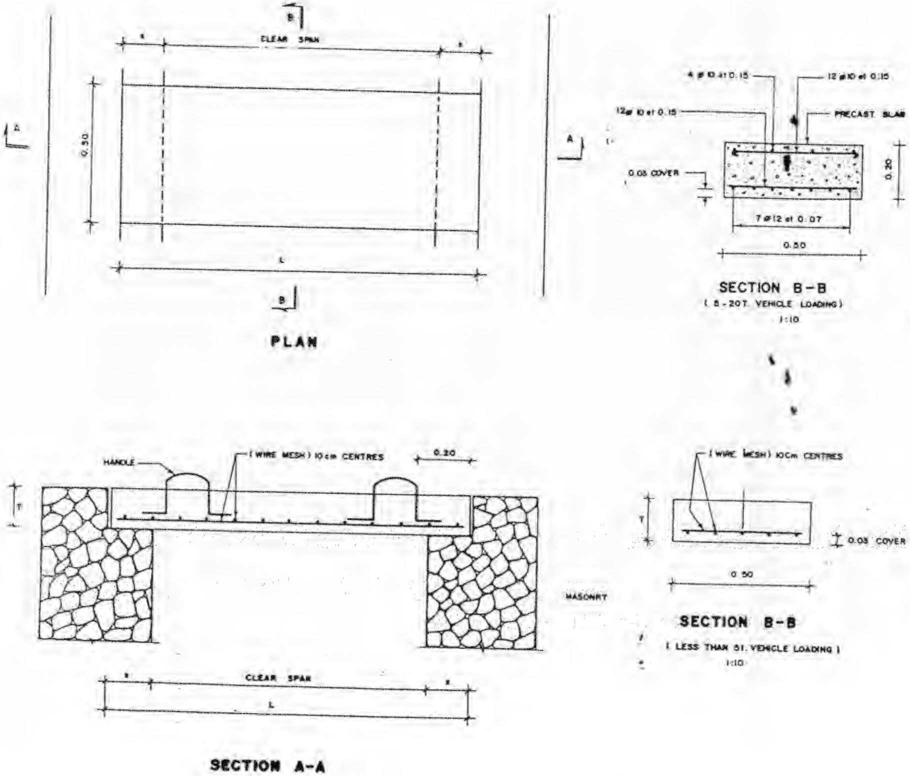
Retained Height [H] (m)	Theoretical Minimum Bottom Width (m)	Wall Top Width (m)	Adopted Bottom Width [b] (m)	Footing Depth [z] (m)	Masonry Volume (m^3)
.50	.28	.50	.50	.4	.45
.60	.33	.50	.50	.5	.53
.80	.44	.50	.50	.6	.74
1.00	.55	.50	.55	.7	1.00
1.20	.66	.50	.66	.9	1.33
1.40	.77	.50	.77	1.0	1.69
1.60	.88	.50	.88	1.1	2.09
1.80	.99	.50	.99	1.2	2.51
2.00	1.10	.50	1.10	1.3	2.96
2.20	1.21	.50	1.21	1.4	3.43
2.40	1.32	.50	1.32	1.4	3.91
2.60	1.43	.50	1.43	1.5	4.40
2.80	1.54	.50	1.54	1.6	4.90
3.00	1.65	.50	1.65	1.6	5.40
3.20	1.76	.50	1.76	1.7	5.89
3.40	1.87	.50	1.87	1.7	6.37
3.60	1.98	.50	1.98	1.8	7.10
3.80	2.09	.50	2.09	1.9	7.87
4.00	2.20	.50	2.20	2.0	8.68

TABLE 5.2 CROSS SECTIONS OF BOX CULVERTS FOR IRRIGATION SCHEMES



Floor Width [W] (m)	Floor Thickness [t] (m)	Masonry Volume (m^3/m)
.40	.30	.12
.50	.30	.15
.60	.30	.18
.70	.30	.21
.80	.30	.24
.90	.30	.27
1.00	.35	.35
1.10	.35	.39
1.20	.35	.42
1.30	.35	.46
1.40	.35	.49
1.50	.40	.60
1.60	.40	.64
1.70	.40	.68
1.80	.40	.72
1.90	.40	.76
2.00	.45	.90

Wall Height [H] (m)	Theoretical Minimum Bottom Width (m)	Wall Top Width (m)	Adopted Bottom Width [b] (m)	Footing Depth [z] (m)	Masonry Volume (m^3)
.70	.39	.50	.5	.40	.53
.80	.44	.50	.5	.45	.61
1.00	.55	.50	.5	.60	.85
1.20	.66	.50	.6	.75	1.18
1.40	.77	.50	.7	.85	1.49
1.60	.88	.50	.8	1.00	1.93
1.80	.99	.50	.9	1.10	2.33
2.00	1.10	.50	1.0	1.20	2.78
2.20	1.21	.50	1.1	1.25	3.15
2.40	1.32	.50	1.2	1.35	3.67
2.60	1.43	.50	1.3	1.40	4.09
2.80	1.54	.50	1.4	1.50	4.68
3.00	1.65	.50	1.5	1.55	5.15
3.20	1.76	.50	1.8	1.60	5.69



SLAB DETAILS FOR LESS THAN 5T. VEHICLE LOADING						
LENGTH L (m)	CLEAR SPAN (m)	SLAB THICK t (m)	BEARING WIDTH (x)	SLAB WEIGHT (Kg)	ADOPTED DIAM	WEIGHT OF REINF/SLAB (Kg)
.70	.50	.10	.10	84	8	2.5
.84	.60	.10	.12	101	8	3.0
.98	.70	.12	.14	141	8	3.5
1.12	.80	.12	.16	161	8	4.0
1.26	.90	.12	.18	181	8	4.5
1.40	1.00	.15	.20	252	10	8.10
1.54	1.10	.15	.22	277	10	8.84
1.68	1.20	.15	.24	302	10	9.80
1.82	1.30	.20	.26	437	10	10.51
1.96	1.40	.20	.28	470	10	11.90
2.10	1.50	.20	.30	504	10	12.21

NOTES:

1 - ALL DIMENSIONS ARE IN METRES EXCEPT AS SHOWN.

2 - CONCRETE DESIGN BASED ON A COMPRESSIVE STRENGTH OF 250 kg/cm^2.

3 - THE TENSILE STRENGTH OF REINF. SHALL NOT BE LESS THAN 2500 kg/cm^2.

4 - WEIGHT OF DEPOSITED MATERIAL ASSUMED TO BE 2000 kg/cm^2.

5 - MINIMUM AREA OF STEEL AS = 0.0025bd.
WHERE b = UNIT WIDTH (0.50m).
d = EFFECTIVE DEPTH = (t - COVER).

6 - WEIGHT OF REINFORCED CONCRETE = 2400 kg/m^3.

7 - WEIGHT OF REINFORCING STEEL = 7850 kg/m^3.

8 - THE ASSUMPTIONS OF LOADING IS FOR DEPTH OF 1.5m SILT AND ONE m. WATER ON SLABS.

DATE	REVISED	
15/01/92		WEIGHT OF REINF. / SLAB CHANGED.
		SECTION B-B CHANGED.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Programme for the Rehabilitation of the Afghanistan Agriculture

Province: District:

Drawing No. K/LK/S.P.S

STANDARD PRECAST SLAB

No	Date	Checked
D		
C		
B	10/11/98	I.Anderson
A	15/01/92	A.H.Zia

REVISIONS

Designed: Abdul Haq Zia	Drawn: Mohd. Ashraf Qadiri	Checked: I. Anderson	Approved: A. R. Fitzherbert
Scale: As shown	Date: November 1992	Project No.	Sheet No. 1 of 1

to date and where any delays in the provision of assistance may restrict water supplies for the coming season. Farmers have a good idea of the canal shape before the war and under the immediate cleaning agreements, they will be required to excavate the deposited material until the former cross section has been achieved. Canals cleaned under these circumstances will be surveyed topographically after initial cleaning and will receive additional funds for final cleaning to ensure that they have sufficient capacity to meet the long term needs of the commanded area.

1.4.3. Inspection Surveys

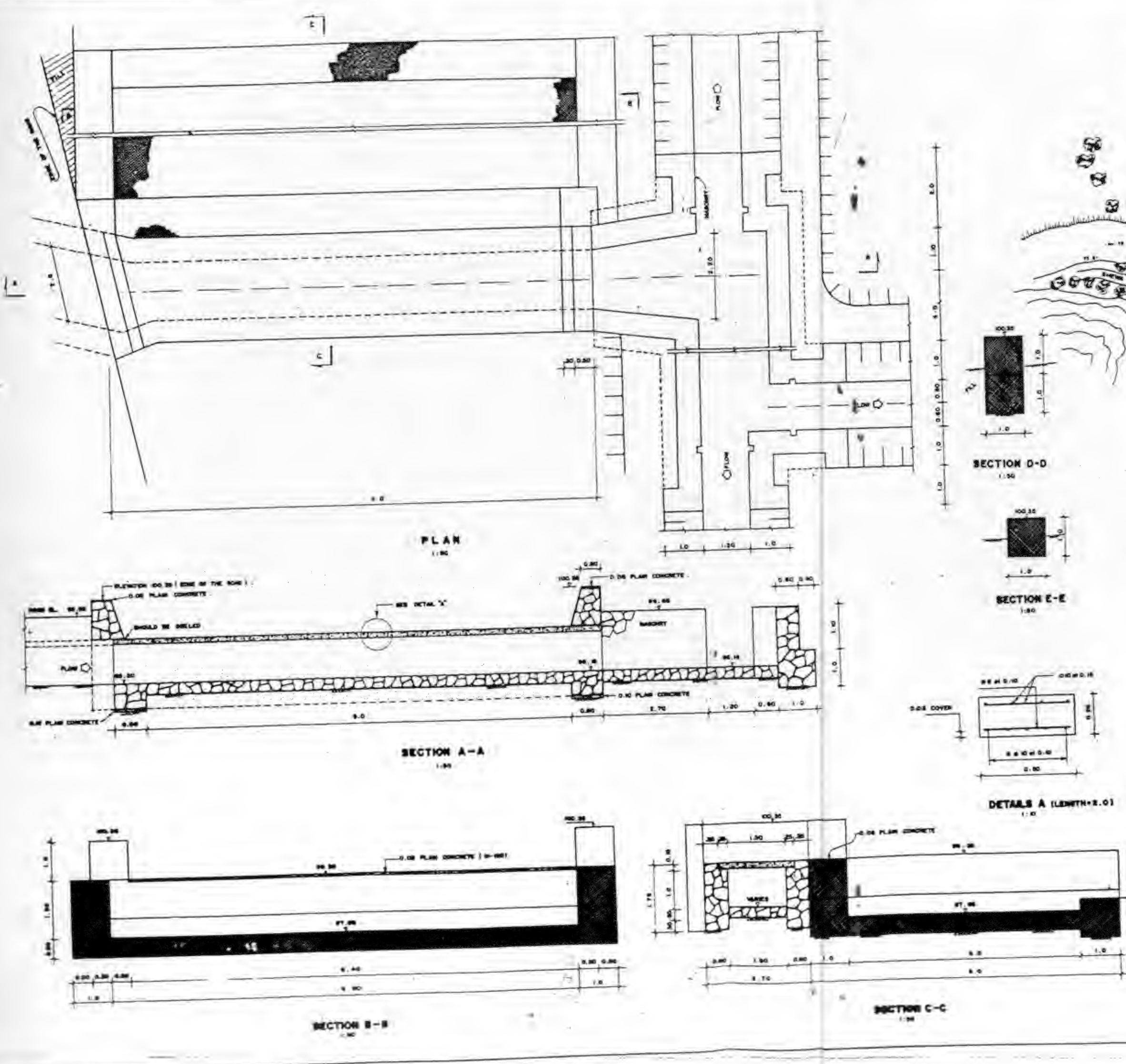
Whilst the immediate cleaning of some of the main canals is being undertaken, inspection surveys will also be carried out. These follow immediately on from the plan surveys and comprise detailed inspection of each canal and the measurement of their lengths. The aim is to confirm the number, length and condition of the canals in the command areas under study and to identify more precisely the parts of each canal system that need attention and the urgency of this attention. Sufficient data should be collected to enable the current condition of the canals to be assessed and the problems that the farmers are experiencing defined. All data collected should be clearly recorded in site survey notebooks together with plans of problem areas, dimensions of existing structures, comments and dimensions and/or levels for the major features already identified and all other pertinent data.

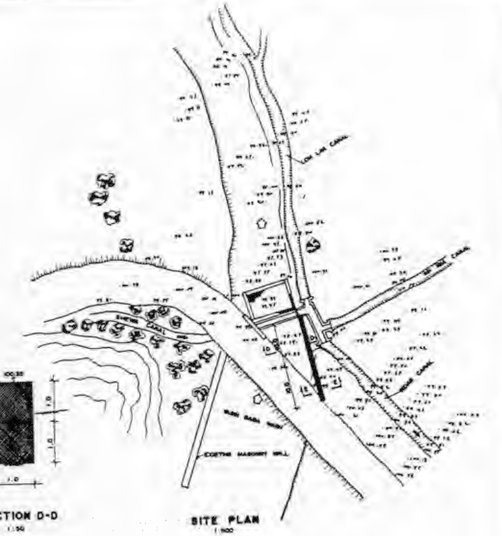
From the above data, an updated priority list for cleaning and more detailed longitudinal and site surveys will derive. This should be accompanied by a work plan based on the identified needs and the above information. An estimate of the time and resources required by the implementing agency to carry out both the further survey work and the immediate cleaning work BY CANAL should also be included. Examples of the priority lists that derive are given at the end of this chapter for the identification of canal priorities and needs (Table 1.3) and for all of the structures required and their estimated priority (Table 1.4).

The inspection or canal layout surveys are essential as they determine the importance of the canal systems, the areas that they command and any major problem areas that may exist (wash crossings; bank erosion; mined areas; etc.;). The plotting of the field data should be carried out at periodic intervals so that a regular supply of data reaches the design office.

1.4.4. Topographical Surveys of Canals

For the more important canals within the identified command areas, topographical surveys of each main, branch and important secondary canal should be carried out according to the identified priority list and work plan. The objective of the surveys is to obtain sufficient data to determine the existing canal cross section, slope and capacity so that points where problems of flat slope and inadequate capacity or where heavy siltation has occurred can be identified for further cleaning. Control points and elevation of land to be commanded are also recorded to indicate whether canal slopes or cross sections can be adjusted to meet the estimated long term requirements. The existing capacity of the

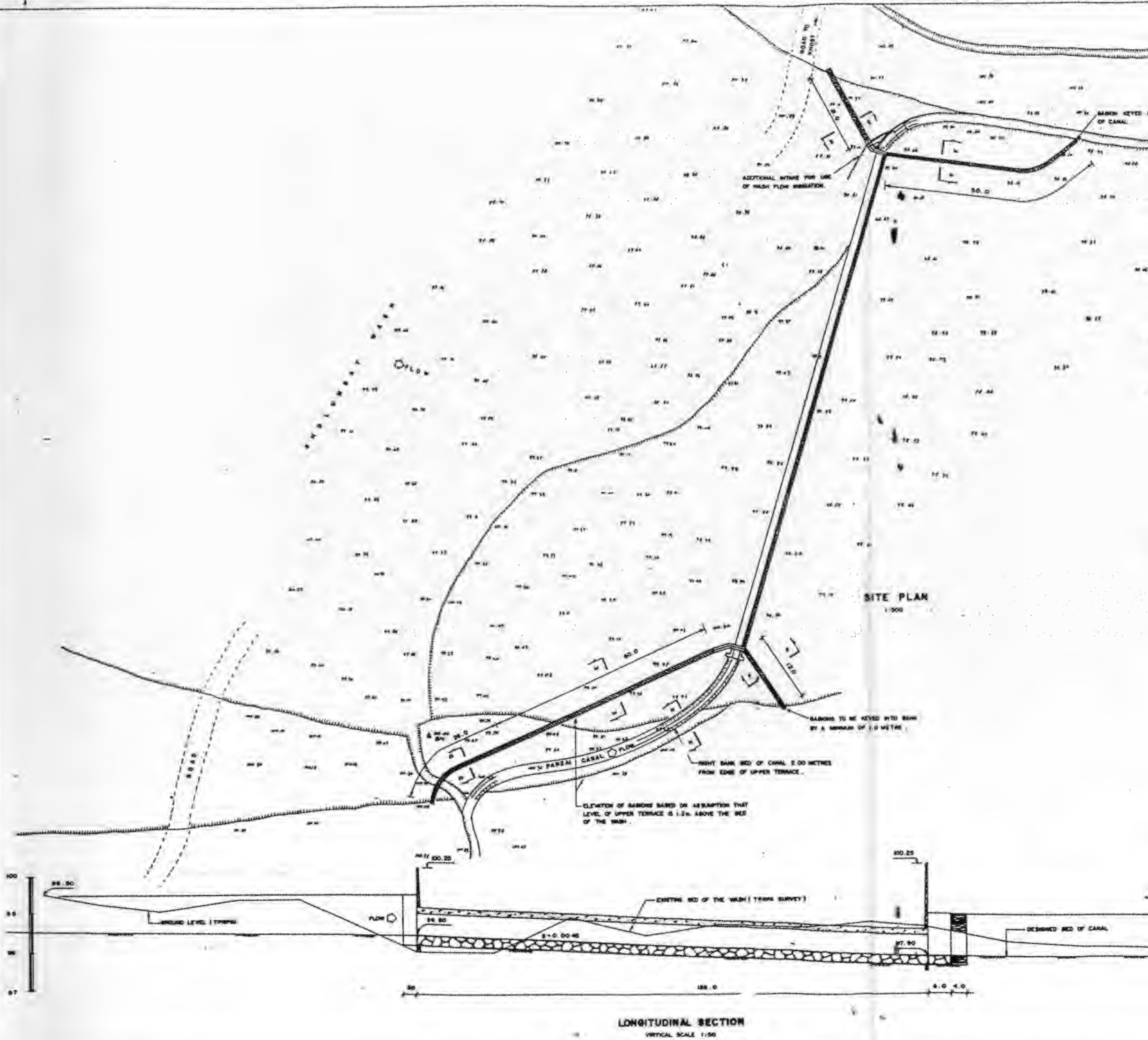


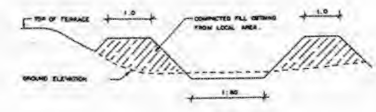


NOTES:

1- ALL DIMENSIONS ARE IN METRES.
2- MORTAR FOR MASONRY IS A MIX OF CEMENT-SAND (1:3)
3- MINOR CHANGES IN ELEVATION MAY BE REQUIRED TO ACCOUNT OF ACTUAL SITE CONDITIONS.
4- THE INSIDE OF THE AQUEDUCT AND THE DIVISION BOX SHOULD BE PLASTERED WITH MORTAR CEMENT SAND (1:2).
5- HANDLES SHOULD BE PROVIDED EVERY OTHER PRECAST SLAB.
6- THE DOWNSTREAM BRANCHES SHOULD BE CLEANED TO MATCH THE DESIGN ELEVATION.
7- SIZE OF STONE FOR FILLING GABION SHOULD BE 0.15 TO 0.30 m.
8- ALL DESIGN SHALL BE DONE AS PER F.A.O TECHNICAL SPECIFICATIONS.
9- FINE SETTING OUT OF STRUCTURE ON SITE TO BE AGREED WITH F.A.O DESIGN ENGINEER.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS			
Programme for the Rehabilitation of the Afghanistan Agriculture			
Province: Nangarhar	District: Shewa		Drawing No: K/S/RB-1
CULVERT STRUCTURE **YASIN BABA WASH- SHEBAY CANAL** PLAN AND SECTIONS			D / C / B / A / No. Date Checked — REVISIONS
Designed: Abdul Haq Zia	Drawn: Mohammad A. Qadari	Checked: Mohammad O. Nabal	Approved: A. R. F'Sabatari
Scale: As shown	Date: 07 / 06 / 1998	Project No: [illegible]	Sheet No: 1 of 1





SECTION H-H

1:50

NOTES:

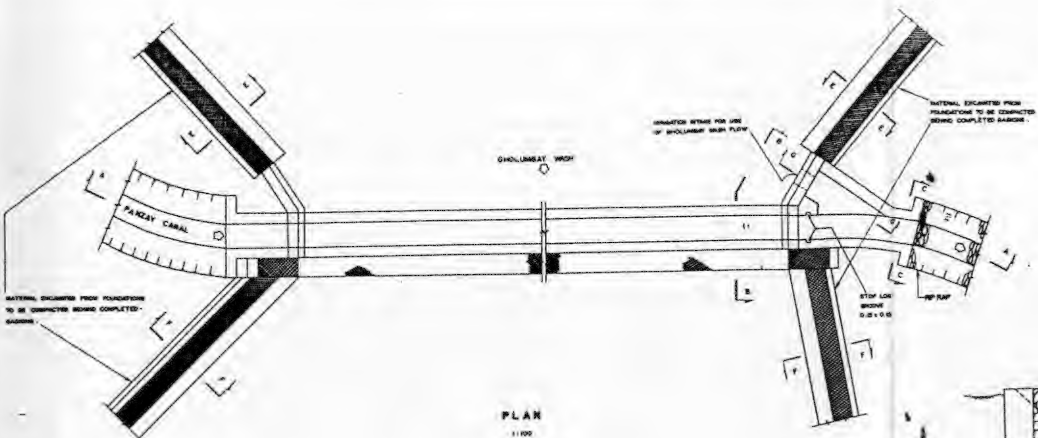
1. ALL DIMENSIONS ARE IN METRES.
2. ALL WORKS SHALL BE DONE AS PER TECHNICAL SPECIFICATIONS.
3. SEE DRAWING NO.(SH LB 3-2) FOR PLAN, SECTIONS AND DETAILS.
4. SEE DRAWING NO.(SH LB 3-2) FOR SECTIONS (D-D, E-E AND F-F).
5. ALL WORKS SHALL BE ACCORDING TO THE STANDARD F.A.O TECHNICAL SPECIFICATIONS.

DATE		
AUG / 1993	REVISED	1. ALL CULVERT DESIGN DATA TO NEW (TPRPA) BENCH MARK WITH ARBITRARY DATUM 102.00 LOCATED BY THE TREE ON THE LEFT BANK OF THE GHOLUMBAY WASH. 2. ALL TOPOGRAPHIC DATA TAKEN FROM (APWO) BENCH MARK WHICH IS NOT THE SAME AS THE (TPRPA) BENCH MARK.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

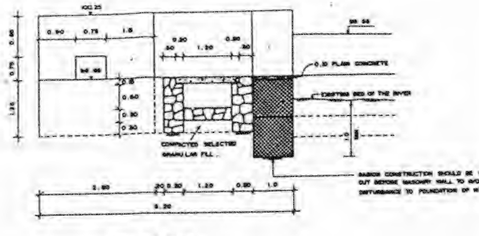
Programme for the Rehabilitation of the Afghanistan Agriculture

Province: Paktia	District: Khost		Drawing No. SH LB 3-1
CULVERT STRUCTURE **PANZAI CANAL-GHOLUMBAY WASH** SITE PLAN AND SECTION			D / C / B / A AUG/1993 I. Anderson / No. Date Checked / REVISIONS
Designed: A. H. Zia	Drawn: M. Ashraf Qadiri	Checked: I. Anderson	Approved: A. R. Fitzherbert
Scale: As shown	Date: 06 / 06 / 1993	Project No. P/93/CD/080/OR	Sheet No: 1of 2



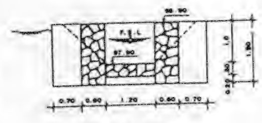
PLAN

1:100



SECTION B-B

1:50



SECTION C-C

1:50

NOTES:

1- ALL DIMENSIONS ARE IN METRES.

2- CONCRETE DESIGN BASED ON A COMPRESSIVE STRENGTH OF 250 kg/cm².

3- MORTAR FOR MASONRY IS CEMENT SAND, RATIO OF 1:3.

4- THE INSIDE OF THE AQUEDUCT AND THE RECTANGULAR LINED SECTION OF CANAL SHOULD BE PLASTERED WITH MORTAR (CEMENT:SAND RATIO OF 1:2).

5- HANDLES SHOULD BE PROVIDED EVERY 5 METRES FOR PRECAST SLAB SEE [illegible].

6- SIZE OF STONE FOR FILLING GABIONS SHALL BE 0.15 TO 0.30m.

7- ALL WORKS SHALL BE ACCORDING TO THE STANDARD F.A.O TECHNICAL SPECIFICATIONS.

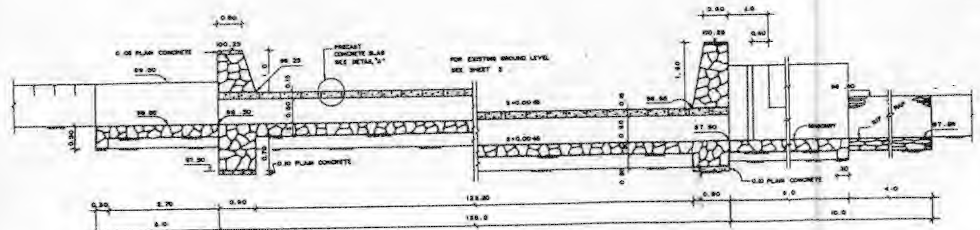
8- SEE DRAWING NO (BHLS 3-1) FOR SITE PLAN AND GABION GUIDE WALLS.

9- DEPTH OF FOUNDATION FOR GABIONS SHALL NOT BE LESS THAN ONE METRE BELOW EXISTING RIVER BED.

10- FOR GABION CONSTRUCTION DETAILS, SEE REVISED CONTRACT SPECIFICATIONS.

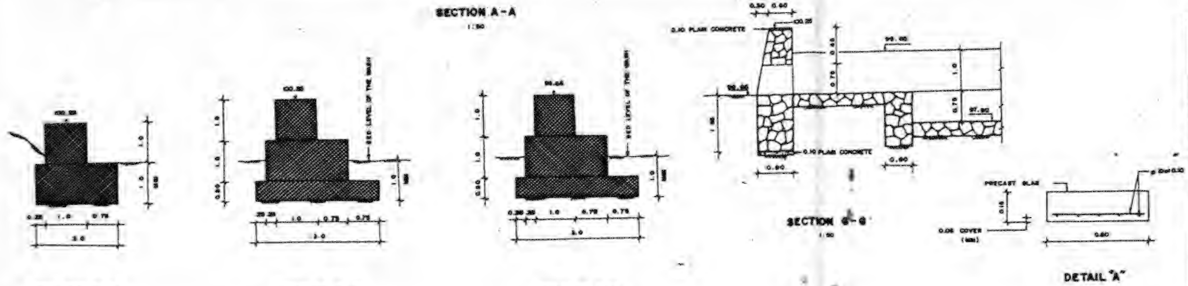
11- CONTRACTOR MUST ADAPT DESIGNS TO SITE CONDITIONS BUT WITH THE PRIOR APPROVAL OF THE ENGINEER (F.A.O).

12- CONTRACTION JOINT (ONE CENTI METRE) SHOULD BE PROVIDED FOR PLAIN CONCRETE AT THE TOP OF CREST OF WEIR AT INTERVAL OF 5.0m.



SECTION A-A

1:50



SECTION D-D 1:50 (SEE SHEET 1)

SECTION E-E 1:50

SECTION F-F 1:50

SECTION G-G 1:50

DETAIL "A" 1:10

DATE	REVISED	
05/06/95		1- ALL CULVERT DESIGN GIVEN TO NEW (T.P.R.A.) BENCH MARK WITH ARBITRARY DATUM 100.00 LOCATED BY THE TREE ON THE LEFT BANK OF THE GHOLUMBAY WASH. 2- ALL TOPOGRAPHIC DATA TAKEN FROM (AFGO) BENCH MARK WHICH IS NOT THE SAME AS THE (T.P.R.A.) BENCH MARK.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Programme for the Rehabilitation of the Afghanistan Agriculture

Province: Ghazni District: Ghazni

Drawing No. BH LS - 3-2

CULVERT STRUCTURE

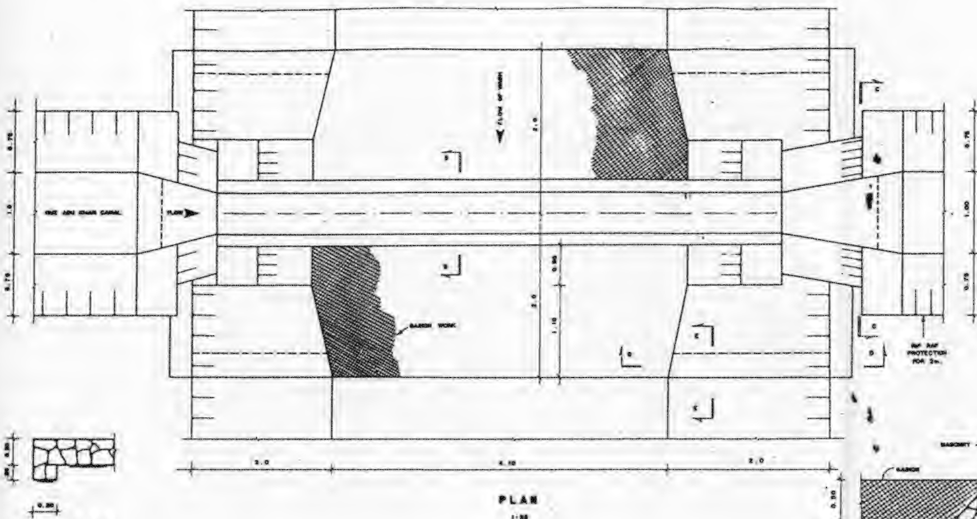
PENZAY CANAL-GHORUMBAY WASH

PLAN, SECTIONS AND DETAIL

No	Date	Checked
D		
C		
B		
A	5/8/95	I.Anderson

REVISIONS

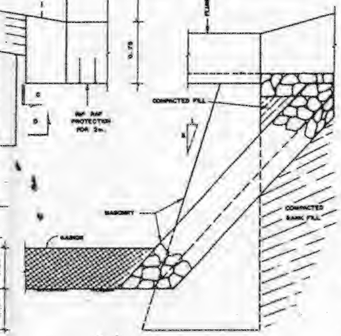
Designed: A. H. Zia	Drawn: M. Ashraf Qadiri	Checked: M. Q. Naimi, I. Anderson	Approved: A. R. Finlayson
Scale: As shown	Date: 05/06/1995	Project No.: F/88/CO/060/[illegible]	Sheet No: 2 of 2



SECTION E-E

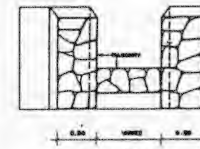
PLAN

1:50



SECTION D-D

1:25



SECTION C-C

1:50

BAR SCHEDULE LIST

BAR No.	BAR DIA. (m m)	SHAPE and LENGTH (Cm.)	NEEDED No.	LENGTH (m.)	TOTAL LENGTH (m)	TOTAL WEIGHT (Kg)	REMARKS
220	8	10 / 50 / 50 / 15	70	1.45	101.5	39.9	
221	10	10 / 75 / 10	47	0.95	44.7	27.7	
222	10	695	4	6.95	27.8	17.3	
223	10	695	4	6.95	27.8	17.3	
224	16	15 / 695 / 15	6	7.35	45.8	65.7	

TOTAL = 170.6 Kg

INCLUDING 5% WASTAGE = 179 Kg

NOTES:

1- ALL DIMENSIONS ARE IN METRES.

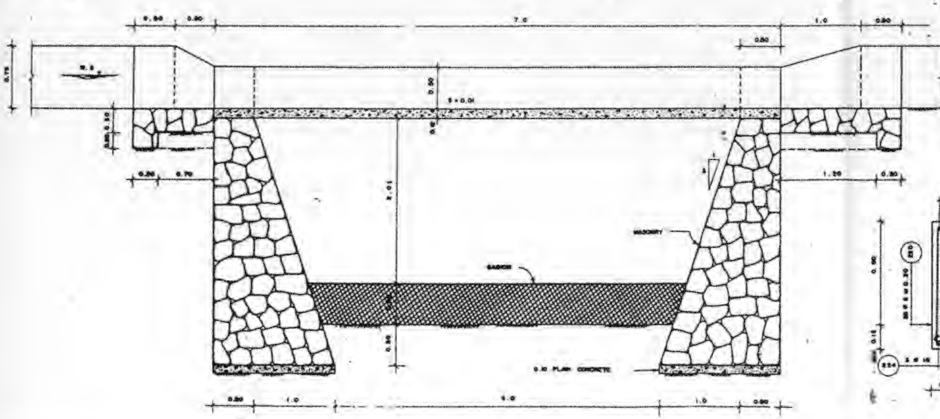
2- CONCRETE DESIGN BASED ON A COMPRESSIVE STRENGTH OF 200 Kg/Cm² at 28 Days.

3- MORTAR FOR STONE WORK SHOULD BE CEMENT : SAND (1:3).

4- ELEVATIONS SHOULD BE FIXED ON THE SITE BY THE SITE ENGINEER.

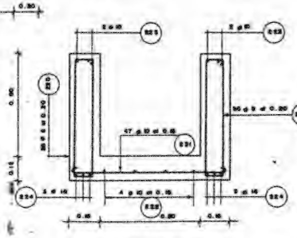
5- SPLICES FOR φ 10 SHALL BE 0.40m. AND FOR φ16 SHALL BE 0.70m.

6- ALL WORKS SHALL BE DONE AS PER TECHNICAL SPECIFICATIONS.



SECTION A-A

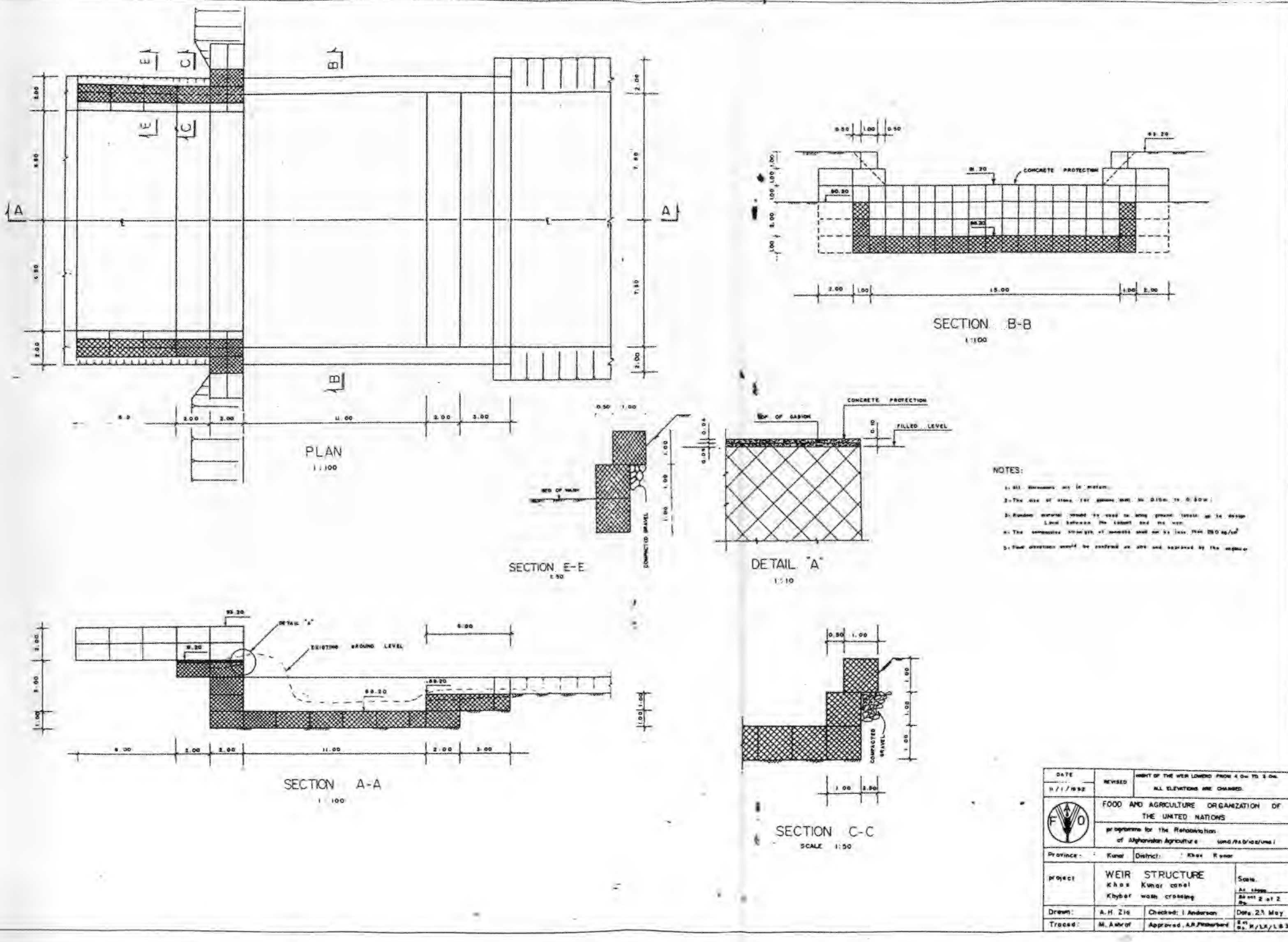
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SECTION B-B

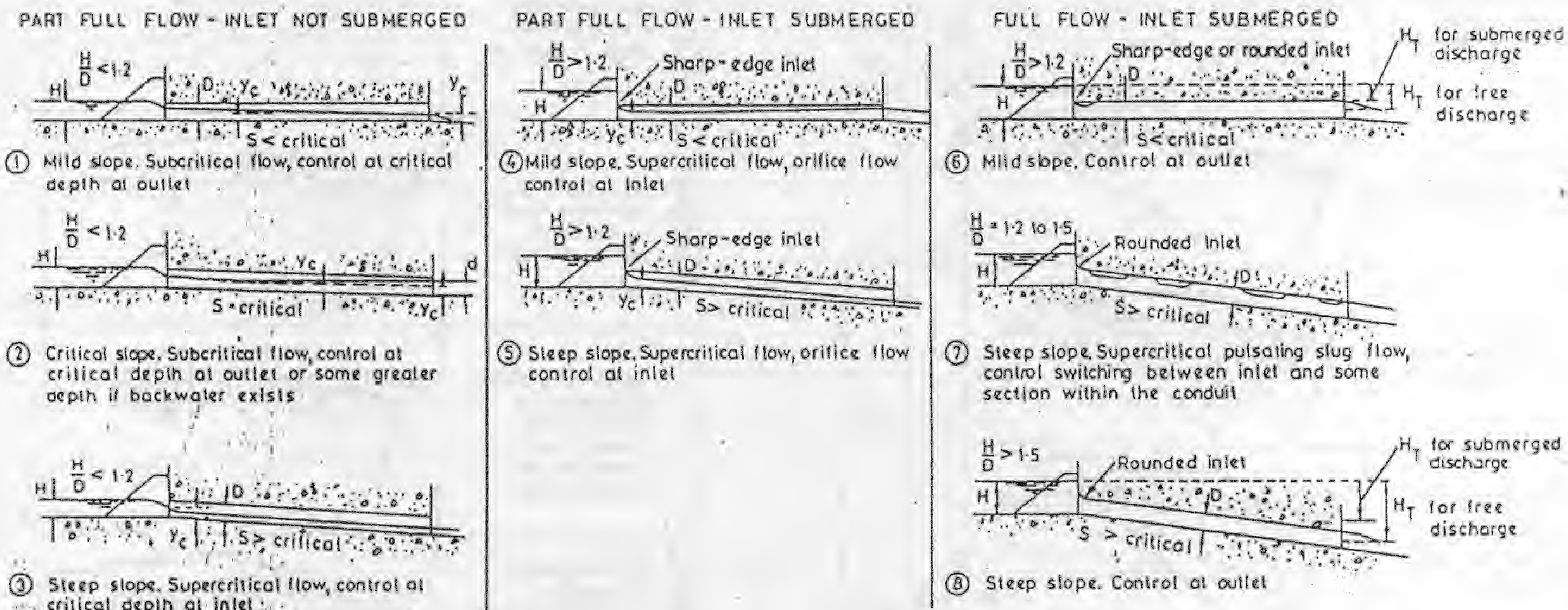
1:10

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS			
Programme for the Rehabilitation of Afghanistan Agriculture			
Province: Paktia	District: Khost		Drawing No.: Z AALLS, 4-2
FLUME STRUCTURE AT STA. 1+570 OF KUZ ABUKHAN Canal PLAN, SECTIONS AND DETAILS			REVISIONS (No. / Date / Checked): D, C, B, A
Designed: A. H. Zia	Drawn: M. Ashraf Qadari	Checked: M. Q. Nabi	Approved: A. R. Pirzadah
Scale: As shown	Date: 27 / 01 / 1993	Project No.: P/CO/93/075-A	Sheet No.: 1 of 1



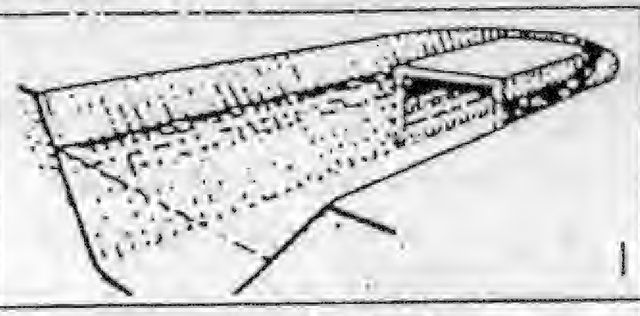
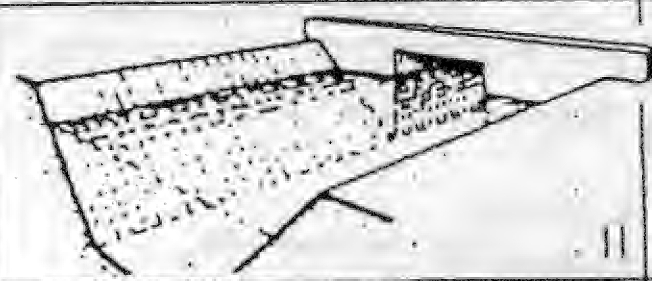
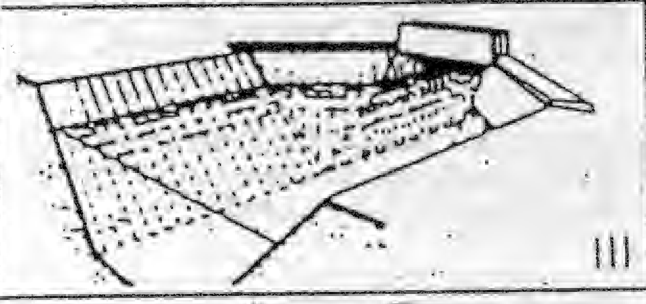
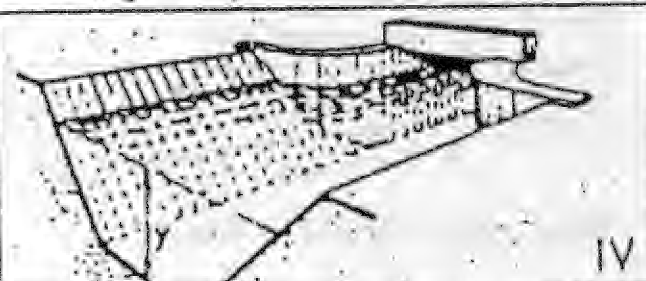
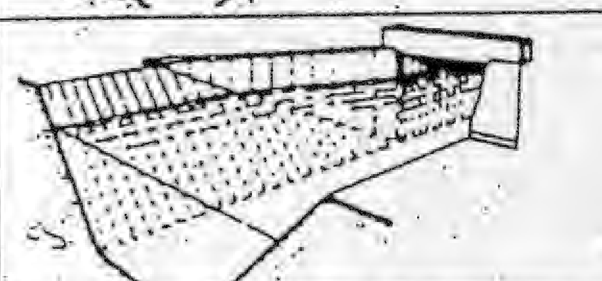
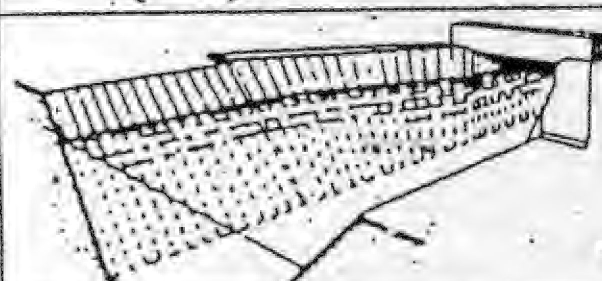
PLAN
1:100
SECTION B-B
1:100
CONCRETE PROTECTION
SECTION E-E
1:50
COMPACTED GRAVEL
DETAIL "A"
1:10
TOP OF GABION
CONCRETE PROTECTION
FILLED LEVEL
NOTES:
1- All ... in ...
2- The size of ...
3- ...
4- The ...
5- ...
SECTION A-A
1:100
DETAIL "A"
EXISTING GROUND LEVEL
SECTION C-C
SCALE 1:50
COMPACTED GRAVEL
DATE
REVISED
ALL ELEVATIONS ARE CHANGED.
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Province:
Kunar
District:
project
WEIR STRUCTURE
Scale.
Drawn:
A. H. Zia
Checked: I. Anderson
Traced:
M. Ashraf

FIGURE 5.3 TYPICAL FLOW CONDITIONS IN CONDUITS ON MILD AND STEEP SLOPES

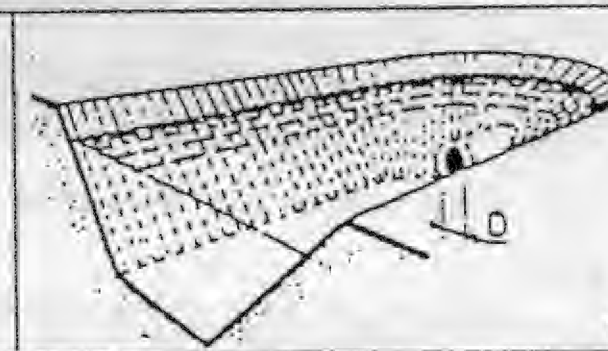
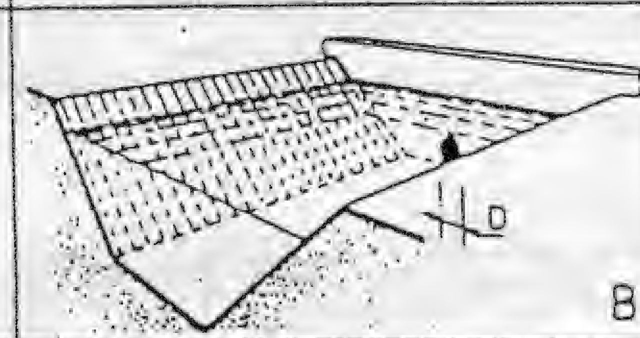
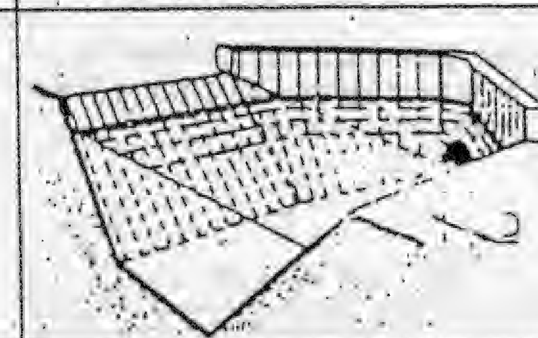
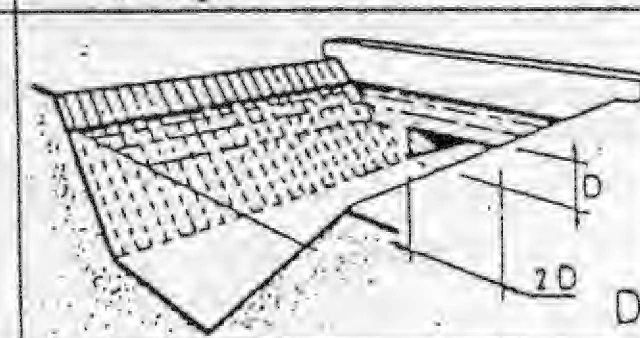
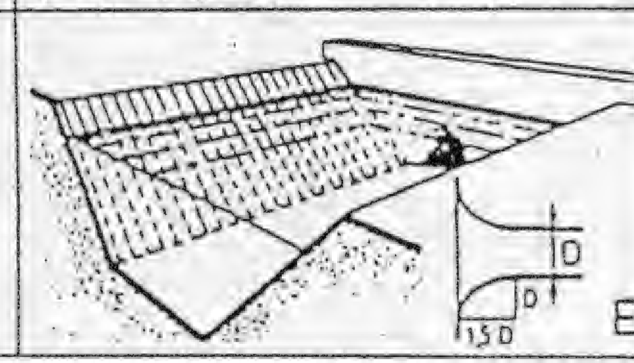


VICE VERSA)

(A) Trapezoidal to rectangula (free water surface)

	Description	Sketch	Type	ζ in	ζ out
	culvert pipe terminates in channel side slope transition		I	0.50	1.00
RECOMMENDED	culvert pipe terminates in headwall across channel		II	0.50	1.00
	broken-back transition with flare angle of 1:1 or 1:2		III	0.30	0.60
RECOMMENDED	headwall with rounded transition of which the radius exceeds 0.1 y		IV	0.25	0.50
RECOMMENDED	broken back transition with flare angle of about 1:5		V	0.20	0.40
	gradual transition between trapezoidal and rectangular cross sections		VI	0.10	0.20

(b) Trapezoidal to pipe

	Description	Sketch	Type	ζ in	ζ out
RECOMMENDED	pipeline terminates in channel side slope transition		A	0.65	1.00
RECOMMENDED	barrel of pipeline connects directly to headwall across channel		B	0.55	1.10
	barrel of pipeline connected to conventional broken-back transition with 1:4 flare angle		C	0.50	0.65
RECOMMENDED	6D-long pipe transition connects pipeline to headwall across channel (round to rectangular)		D	0.40	0.10
	barrel to pipeline connected to bellmouth transition; ellips with axis of D:1.5 D		E	0.10	0.20

6. COSTING OF PROJECT WORKS

6.1. Introduction

At the start of the FAO programme, preliminary costs for the structural work to be undertaken were established on the basis of generalized designs. With the development of the programme, these were expanded upon using the detailed designs and construction drawings prepared for each of the proposed engineering works. The costs have been presented in two ways:

(a) **Total Costs of the Structure/Improvement.** The quantities that have been determined for each structure/improvement works are multiplied by the revised unit rates to give the total development costs of the works. Site supervision and physical contingencies are included in this cost.

(b) **Costs to be Paid by FAO and by NGOs.** The costs are divide up into those that FAO pay directly and those that FAO pays the NGOs for carrying out the work. In general, FAO provides all the input materials and the NGO constructs the works and supplies site Engineers/Supervisors for the field activities.

The way in which the costs have been built up is discussed below and these are supported by appropriate tables at the end of this chapter. Although unit costs will change with time, the actual values have been given in this chapter so that the basis for the estimates can be clearly seen together with the way in which the costs were compiled. A more meaningful way of expressing some of the excavation and placement costs is as a proportion of the labour involved in absolute terms. As detailed data are enclosed, the reader can easily adjust them to comprehend their own assumed unit rates and outputs.

6.2. Construction Costs

All construction items have been broken down into their basic constituents in order to determine whether the costs will be borne directly by FAO or reimbursed to the NGOs. It has been assumed that all construction materials and equipment not readily available within the Afghanistan are purchased by FAO and transported to a store located at a strategic point within the area to be assisted. These materials are released to the NGOs according to the quantities estimated in the designs for the structure concerned. The items included are:

- Cement
- Reinforcement
- Gabions
- Small construction Equipment

6.2.1. Equipment Costs

In the beginning of the programme, FAO purchased items of small construction equipment that was used by the NGOs for the structural works. The costs of these equipment have been paid out of the allowance for depreciation of equipment provided in each unit rate. The NGO running costs have also been allowed for in the determination of the unit rates.

6.2.2. Unit Rates

The base cost of input materials and labour shown in Table 6.1 have been used to determine the unit cost of construction items presented in Table 6.2. All input costs have been considered including material purchase, labour, transportation and placement costs. Depending on whether the item is related to input materials & equipment or the costs of construction, they have been assigned to either FAO (the former) or the implementing NGO (the latter). This is illustrated in Table 6.3.

Summary unit rates used for final costing of each structures are presented in Table 6.4

6.2.3. Construction Materials

All materials available within the area to be assisted (sand; aggregate; stones;) have been assumed to be within easy reach of each construction site. The unit costs of these items include the loading and unloading by hand and the cost of transport within a radius of 3.5 km of the site. Following the results of field concrete testing, additional cement have been included in the concrete mixes to ensure that the required strengths are achieved.

6.2.4. Bills of Quantities

In Table 6.5 the standard form for the bill of quantities that is used for each structure/improvement is shown. Also given is the breakdown in materials and costs under the main headings. This is aimed at assisting both the donor as well as the implementing NGOs in the planning of the work and the supply of materials and equipment to site. For each project, a bill of quantities giving the total cost of the project is produced. These detailed cost tables form part of the agreement with the implementing NGO as shown in Appendix B.

6.3. Engineering and supervision costs

Engineering and supervision costs of the NGOs been included as a fixed percentage (10%) of the base cost of the works. This has been determined using the actual cost of the site supervision staff together with an allowance for site transport. These have been included in the cost summary as NGO costs. The costs of FAO supervision of the NGOs is covered under an overhead item included under the overall Afghan Rehabilitation Programme Budget and therefore is not be shown as a cost to any one

structure.

Because of the uncertainties relating to the construction capabilities of the NGOs, and the variable security situation in some areas, physical contingencies have been included at 10% of the base cost. This allowance is kept as reserve in case adverse site conditions and other problems are encountered during construction.

Supervision of construction is entrusted to the NGO implementing partner with estimates of the costs involved being made on the basis of a fixed percentage (10%) of the base construction cost. For the larger agreements, this has proved to be a reasonable sum and adequately covers costs incurred by the NGO. A recent review of these costs carried out by the Consultant following the Irrigation Design Workshop, show that for the smaller contracts, the allowance is insufficient.

Although the standard cost spreadsheet prepared for each construction agreement automatically determines the supervision cost, this must be checked for each construction agreement. In Table 6.6, an estimate has been made of the average monthly supervision costs of the NGOs in Eastern Paktia, Nangarhar and Laghman (Rs.32,600) and in Kunar (Rs.30,600). The data in this Table should be utilized, together with the estimate of time allocated for construction supervision given in the project work plan that is prepared for each project, to assess whether the actual allocated costs are compatible with the construction period.

Where supervision costs amount to more than 20% of the construction costs, the proposed project must either be combined with another construction agreement in the area or the work plan re-assessed in order to reduce the costs.

6.4. Work plan

This plan includes an allowance for mobilization, setting up the site camp and delivery of materials to site. As a number of similar projects have been already constructed under the FAO Programme for the rehabilitation of Afghanistan, it is possible to now estimate reasonably accurately the time required for construction.

6.4.1. Mobilization and Setting up of Site Camp

Before construction work begins on site, it is important that the NGO assigned to the work discusses the project with the beneficiaries. This is to ensure that they understand fully the works that will be undertaken and what will be required of them in terms of free labour contributions, accommodation for NGO staff and storage of materials. Although this will have been discussed at several stages during the planning and design process, one week to ten days lead time should be allowed for the average one to two months construction agreement.

main and branch canal systems can then be related to the estimated full supply capacity of the main canals throughout the command area and the amount of material that needs to be removed quantified. The details that are required from these surveys are discussed in the next chapter.

1.4.5. Canal Design

As the survey data are received from the field, long sections for the canals are prepared and the design of the canals carried out. This relates canal flow to command area and includes allowances for head loss across new structures that have been identified as being needed in the future. This is discussed in detail in Chapter 3.

1.5. Stage III - Topographical survey of sites for structures and final canal cleaning

1.5.1. Surveys of Sites for Structures

During Stage III, topographical surveys will be carried out at those locations that have been identified as needing improvements to existing structures or where new structures are required. These detailed site surveys are executed using the same bench mark that was used for the longitudinal surveys of the canals and are aimed at ensuring that sufficient data are collected to enable the most suitable structure to be selected. The surveys normally take from three to ten days field survey work, depending upon the site, followed by the same time in the office for plotting the results.

It is normal that agreements are signed for the survey of a number of structures sites and it is essential that after completion of one site the results are plotted to ensure that a steady flow of data reaches the design Engineers.

1.5.2. Structure Design and Construction Planning

Once the site survey data is received by the design Engineers, a plan of the site is prepared and the site levels related to the canal levels. Design water levels, invert levels and head losses are all examined to determine which type structure would be most suited to the site. Standard designs developed under the FAO Rehabilitation Programme (see Chapter 5) are utilized and once selection of the type of structure has been made, these are adapted to the particular site conditions using the canal design prepared under Stage II. The draft designs are then checked on site and, after modifications have been made, final drawings, a description of the works to be carried out and detailed bills of quantities, costs and construction work plans are prepared.

1.5.3. Final Canal Cleaning

Following the survey of the canals after the initial cleaning and the preparation of the canal designs

6.4.2. Construction Period

From the projects already constructed, the average time for construction can be summarized in the following range:

Type of Project	Location	Approx. Length	Estimated Construction period (Days)		
			Mobilization Etc.	Const.	Total
Intake Structures	All	10	7	40	47
Spillways	All	15	7	40	47
Flume Crossing	All	8	7	45	52
Erosion Protection (Washes)	All	30	10	45	55
Wash Crossing/Culvert	All	25	10	60	70
Bank Protection (Rivers)	All	100	10	70	80

6.5. Reporting costs

The costs of reporting in most cases have been assumed to be included in the overall project costs. With the more detailed reporting that has been recently requested of the implementing NGOs, additional costs will be incurred. It is thus recommended that a separate lump sum cost is provided in the agreements with the NGOs. This should again be assessed for each individual contract on the basis of the work involved and the project location, and should represent no more than two percent of the overall project cost. The reporting costs are thus expected to lie between Rs.2000 and Rs.5000 for the average agreement with three to four reports required.

6.6. Contingencies

(a) Physical Contingencies. There has been some confusion over the reason for including contingencies in the project costs and the use to which it should be put. Because it is not possible to have sufficient detailed information on each project site, a ten per cent contingency has been included to cover unforeseen items such as the need to extend the depth of the foundations due to poor soil conditions or to provide additional minor works items when adapting the designs to site situations. In addition, if there have been delays due to design modifications during construction or delivery of material and equipment to site by FAO, then these would also be covered under this contingency item. At the end of the Project, if these funds are not used in construction, then they are returned back to the main project funds for use on additional works.

(b) Security Contingency. Occasionally during construction, trouble has flared up unexpectedly, thereby delaying or resulting in a complete halt in the works. A separate security contingency of 5%

has been included, mainly in those areas of new intervention, to cover this case. This can only be drawn upon if the NGO advises FAO without delay of the problem, that a detailed record is kept by the NGO of the security situation and the effect that they had on the construction works, and FAO has agreed for the contract to continue and not be terminated.

(c) Overall Project Contingency. On some sites additional works are required due to damage occurring after the main works have been constructed, further request from the farmers, or major changes resulting from a detailed check during implementation. No contingency has been included under this component at present, however, it is recommended that an additional 5% of committed costs are kept in a separate fund to permit both the maintenance of the constructed works in the first or second year after construction and also to cover the extra previously unidentified but associated works.

(d) Price Contingency. The costs in Afghanistan fluctuate widely depending on the demand in the areas and security situation to and within the area. As most imported construction materials (cement; steel; gabions) derive from Pakistan, costs have been prepared using Pakistani Rupees. Under the FAO Irrigation Assistance programme, all construction materials and equipment are procured by FAO and delivered to the site of construction or the designated store in the area. This takes the onus of price escalation away from the NGO and it has been found that the overall costs considering both FAO projects (102 & 103) have been within the planned budgets.

Where NGOs are purchasing materials themselves, they tend to monitor the prices within Afghanistan, and if they increase excessively, then they import the materials themselves from Pakistan. They suffer more problems in this respect as they have to cover the internal and border transport charges of which FAO is exempt.

6.7. Survey costs

Following the execution of the recent surveys in Laghman and Surkhrud command areas, a review of the actual costs experienced by the NGOs has been carried out. These were discussed during the recent workshop, and modified recommendations a survey costs have been prepared in Tables 6.7 to 6.9. These can be summarized as follows:

Type of Survey	Province	Cost per month (Rs.)
1. Canal plan and long survey.	Kunar, Nangarhar and Laghman	53,600
2. Canal plan and long survey.	Eastern Paktia	55,600
3. Structure site survey.	All FAO Provinces	42,600
4. Survey plotting in home offices in Peshawar for all types of survey.	All FAO Provinces	42,590

These costs should be used in the planning of all future surveys. For periods of less than one month in the field, they should be adapted on a pro-rata basis with allowance being made for travel to and from the project area. In all cases, the costs of surveys should not exceed more than 15% of the estimated total cost of the structure that will be built on the site.

6.8. Summary

The total costs of all future projects should be assessed by adding the following percentages to the base cost. These should not be accepted blindly as being correct, but be cross checked as set out in the sections above.

Contingency item	Percentage of Base cost	
Physical	10.0	
Price	0.0	
Security	5.0	
Reporting	2.0	
Overall Project	5.0	Retained in main Budget.

6.9. Cost Curves

Using the experience gained from the programme to date, cost curves for the main structures have been estimated in Figures 6.1 to 6.5. These data have been recently updated considering the actual costs of completed structures. Whereas they are not intended to replace the detailed costing of structures, they provide a planning tool to assist Engineers in the planning of their construction works.

TABLE 6.1 BASE COST OF INPUT MATERIALS AND LABOUR

Item		Description	Unit (Rp)	Cost
1		LABOUR		
	1.1	Unskilled	Day	50.00
	1.2	semi-skilled	Day	80.00
	1.3	skilled	Day	120.00
	1.4	Surveyor	Day	160.00
	1.5	Site Supervisor	Day	200.00
	1.6	Site Engineer	Day	260.00
2		MATERIALS		
	2.1	Cement (ex Peshawar) [59kg]	bag	145.00
	2.2	Sand (at source)	m^3	200.00
	2.3	Gravel (at source)	m^3	150.00
	2.4	Aggregate (at source)	m^3	150.00
	2.5	Stone for Pitching (at source)	m^3	100.00
	2.6	Stone for Gabions (at source)	m^3	105.00
	2.7	Stone for Masonry (at source)	m^3	150.00
3		PIPEWORK (ex Peshawar)		
	3.1	Unreinforced concrete pipe diametre 60cm	m	480.00
	3.2	Unreinforced concrete pipe diametre 80cm	m	700.00
	3.3	Unreinforced concrete pipe diametre 100cm	m	1000.00
4		GABIONS (ex Peshawar)		
	4.1	Gabion basket (2m*1m*.5m)	pc	
	4.2	Gabion basket (2m*1m*1m)	pc	800.00
	4.3	Gabion basket (2m*1m*.3m)	pc	
	4.4	Wire for fixing Gabions	kg	25.00
5		TIMBER		
	5.1	Timber planks for Shuttering	m^3	8000.00
	5.2	Timber poles	m^3	8000.00
6		REINFORCING STEEL (ex Peshawar)		
	6.1	Reinforcing Mesh (.10x.10) [dia 6mm]	m^2	17.00
	6.2	Reinforcing steel - Bar (mild) [dia 6mm]	kg	16.00
	6.3	Reinforcing steel - Bar (mild) [dia 12mm]	kg	16.00
	6.4	Reinforcing steel - Bar (mild) [dia 16mm]	kg	16.00
7		EQUIPMENT		
	7.1	Tractor 65hp	No	400000.00
	7.2	Tipping Trailor for Tractor (4t)	No	100000.00
	7.3	Concrete mixer (500 l cap.) - Diesel	No	125000.00
	7.4	Concrete mixer (200 l cap.) - Diesel	No	36000.00
	7.5	Concrete mixer (100 l cap.) - Diesel	No	25000.00
	7.6	Concrete vibrator - Petrol	No	17500.00
	7.7	Water trailer (2 wheels) 2250 litres	No	19000.00
	7.8	Generator 12 kva	No	130000.00
	7.9	Rock Breaker + attachments	No	100000.00

TABLE 6.2 COST OF BASIC CONSTRUCTION ITEMS

Item	Description	Unit	Rate (Rp)	FAO Cost (Rp)	FAO Cost (%)	NGO Cost (Rp)	NGO Cost (%)
1	GABIONS	Rp/m³	700.50	245.00	35%	455.50	65%
1.1	Gabion basket delivered Peshawar (2x1x1)	/m³	200.00	200.00			
1.2	Cost of securing wire @ 10% basket cost	/m³	20.00	20.00			
1.3	Delivery to Kunar @ Rp 1500/ton, 30 baskets per t. wire included	/m³	25.00	25.00			
1.4	Transport to site @ Rp8/t/km assuming av. haul dist of 50 km & 25 baskets/pickup	/m³	8.00			8.00	
1.5	Cost of final excavation @ 0.75 manday	/m³	33.75			33.75	
1.6	Collection of stones assuming round trip haul of 4.0 km and Rp150/m³	/m³	249.50			249.50	
1.7	Placement of stones in basket	/m³	45.00			45.00	
1.8	Wiring of basket after filling	/m³	29.25			29.25	
1.9	Backfilling around gabion/site cleaning	/m³	90.00			90.00	
2	CONCRETE WORKS (Placed) - Mass	Rp./m³	990.00	623.88	63%	366.13	37%
2.1	Proportion of capital cost of mixer Rs 36000, 2500 hr. life & 0.8 m³/hr. output	/m³	18.00	18.00			
2.2	Proportion of capital cost of vibrator @ Rs 17500, 2500 hr. life & 2.0 m³/hr. output	/m³	3.50	3.50			
2.3	Proportion of capital cost of water bowser Rs 19000 and life of 10000 hr.	/m³	2.38	2.38			
2.4	Proportion of other small equipment for mixing and placement of concrete	/m³	2.00			2.00	
2.5	Running cost of mixer and vibrator considering operators and O&M cost	/m³	55.38			55.38	
2.6	Cement for a mix of 1:3:6 (200 kg)	/m³	640.00	600.00		40.00	
2.7	Aggregate cost	/m³	135.00			135.00	
2.8	Sand	/m³	100.00			100.00	
2.9	Placement and curing cost	/m³	33.75			33.75	
3	CONCRETE WORKS (Placed) - Reinforced Base	Rp./m³	1859.33	1257.21	68%	602.13	32%
3.1	Proportion of capital cost of mixer Rs 36000, 2500 hr. life & 0.8 m³/hr. output	/m³	18.00	18.00			
3.2	Proportion of capital cost of vibrator @ Rs 17500, 2500 hr. life & 2.0 m³/hr. output	/m³	3.50	3.50			
3.3	Proportion of capital cost of water bowser Rs 19000 and life of 10000 hr.	/m³	2.38	2.38			
3.4	Proportion of other small equipment for mixing and placement of concrete	/m³	2.00			2.00	
3.5	Running cost of mixer and vibrator considering operators and O&M cost	/m³	55.38			55.38	
3.6	Cement for a mix of 1:2:4 (300 kg)	/m³	960.00	900.00		60.00	
3.7	Aggregate cost	/m³	135.00			135.00	
3.8	Sand	/m³	100.00			100.00	
3.9	Reinforcing mesh	/m³	333.33	333.33			
3.10	Shuttering (used 3 times)	/m³	144.00			144.00	
3.11	Placement and curing cost	/m³	105.75			105.75	

TABLE 6.2 COST OF BASIC CONSTRUCTION ITEMS/continued

Item	Description	Unit	Rate (Rp)	FAO Cost (Rp)	(%)	NGO Cost (Rp)	(%)
4	CONCRETE WORKS (Precast) - Reinforced Slab	Rp./m³	2120.00	1573.88	74%	546.13	26%
4.1	Proportion of capital cost of mixer Rs 36000, 2500 hr. life & 0.8 m³/hr. output	/m³	18.00	18.00			
4.2	Proportion of capital cost of vibrator @ Rs 17500, 2500 hr. life & 2.0 m³/hr. output	/m³	3.50	3.50			
4.3	Proportion of capital cost of water bowser Rs 19000 and life of 10000 hr.	/m³	2.38	2.38			
4.4	Proportion of other small equipment for mixing and placement of concrete	/m³	2.00			2.00	
4.5	Running cost of mixer and vibrator considering operators and O&M cost	/m³	55.38			55.38	
4.6	Cement for a mix of 1:2:3 (350 kg)	/m³	1120.00	1050.00		70.00	
4.7	Aggregate cost	/m³	135.00			135.00	
4.8	Sand	/m³	100.00			100.00	
4.9	Reinforcing mesh	/m³	500.00	500.00			
4.10	Shuttering (used 3 times)	/m³	96.00			96.00	
4.11	Placement and curing cost	/m³	87.75			87.75	
5	CONCRETE WORKS (Placed) - Reinforced + Bars	Rp./m³	2370.00	1721.88	73%	648.13	27%
5.1	Proportion of capital cost of mixer Rs 36000, 2500 hr. life & 0.8 m³/hr. output	/m³	18.00	18.00			
5.2	Proportion of capital cost of vibrator @ Rs 17500, 2500 hr. life & 2.0 m³/hr. output	/m³	3.50	3.50			
5.3	Proportion of capital cost of water bowser Rs 19000 and life of 10000 hr.	/m³	2.38	2.38			
5.4	Proportion of other small equipment for mixing and placement of concrete	/m³	2.00			2.00	
5.5	Running cost of mixer and vibrator considering operators and O&M cost	/m³	55.38			55.38	
5.6	Cement for a mix of 1:2:3 (350 kg)	/m³	1120.00	1050.00		70.00	
5.7	Aggregate cost	/m³	135.00			135.00	
5.8	Sand	/m³	100.00			100.00	
5.9	Reinforcing bars (@ 3.5% by weight)	/m³	1008.00	1008.00			
5.10	Shuttering (used 3 times)	/m³	144.00			144.00	
5.11	Placement and curing cost	/m³	141.75			141.75	
6	EARTHWORKS						
6.1	General excavation including disposal	Rp./m³	30.00			30.00	100%
6.2	Excavation for structures	Rp./m³	60.00			60.00	100%
6.3	Backfill for structures	Rp./m³	30.00			30.00	100%
6.4	Trimming of canal banks to finish section	Rp./m³	7.50			7.50	100%
7	ROCK EXCAVATION						
7.1	Excavation in hard murram inc. disposal	Rp./m³	60.00			60.00	100%
7.2	Excavation in conglomerate	Rp./m³	75.00			75.00	100%
7.3	Excavation in soft rock	Rp./m³	90.00			90.00	100%
7.4	Excavation in hard rock	Rp./m³	225.00			225.00	100%

TABLE 6.2 COST OF BASIC CONSTRUCTION ITEMS/continued

Item	Description	Unit	Rate (Rp)	FAO Cost (Rp)	FAO Cost (%)	NGO Cost (Rp)	NGO Cost (%)
8	MASONRY IN WALLS OR FLOORS	Rp./m³	926.00	336.25	36%	589.75	64%
8.1	Proportion of capital cost of mixer Rs 36000, 2500 hr. life & 0.8 m³/hr. output	/m³	15.00	15.00			
8.2	Proportion of capital cost of water bowser Rs 19000 and life of 10000 hr.	/m³	6.25	6.25			
8.3	Proportion of other small equipment for mixing and placement of concrete	/m³	2.00			2.00	
8.4	Running cost of mixer and vibrator considering operators and O&M cost	/m³	53.75			53.75	
8.5	Cement for a mix of 1:3	/m³	336.00	315.00		21.00	
8.6	Sand	/m³	78.00			78.00	
8.7	Cost of mason	/m³	120.00			120.00	
8.8	Stone	/m³	180.00			180.00	
8.9	Labour for mixing and carrying	/m³	135.00			135.00	
9	DRY STONE PITCHING	Rp./m³	390.00			390.00	100%
9.1	Stone	/m³	180.00			180.00	
9.2	Cost of mason	/m³	120.00			120.00	
9.3	Labour for carrying and trimming base	/m³	90.00			90.00	
10	GROUTED RIPRAP	Rp./m³	881.00	336.25	38%	544.75	62%
10.1	Stone	/m³	180.00			180.00	
10.2	Cost of mason	/m³	120.00			120.00	
10.3	Labour for carrying and trimming base	/m³	90.00			90.00	
10.4	Proportion of capital cost of mixer Rs 36000, 2500 hr. life & 0.8 m³/hr. output	/m³	15.00	15.00			
10.5	Proportion of capital cost of water bowser Rs 19000 and life of 10000 hr.	/m³	6.25	6.25			
10.6	Proportion of other small equipment for mixing and placement of concrete	/m³	2.00			2.00	
10.7	Running cost of mixer considering operators and O&M cost	/m³	53.75			53.75	
10.8	Cement for a mix of 1:3	/m³	336.00	315.00		21.00	
10.9	Sand	/m³	78.00			78.00	
11	REINFORCING STEEL	Rp./m³	100.04	70.45	70%	29.60	30%
11.1	6mm steel bar (ex Peshawar) (4.76 kg/m²)	/m²	63.31	63.31			
11.2	Delivery to Kunar @ Rp 1500/ton	/m²	7.14	7.14			
11.3	Transport to site @ Rp 8/t/km assuming average haul dist. of 50 km & 1t/pickup	/m²	1.90			1.90	
11.4	Cost of fixing steel on site	/m²	27.69			27.69	

TABLE 6.3 DIVISION OF COSTS BETWEEN FAO AND NGOs

ITEM	DESCRIPTION	UNIT	RATE (Rp.)	FAO Cost (Rp.)	FAO Cost (%)	NGO Cost (Rp.)	NGO Cost (%)	Cement (bags)	Reinforcement mesh (m2)	Reinforcement bars (Kg.)	Aggregate (m3)	Sand (m3)	Stone masonry (m3)	Stone Pitch. (m3)	Stone Gabion (m3)	Timber formwork (m3)	Labour semi-skilled man/day	Labour Mason man/day	Labour Equip. Op. man/day	Capital Equipment cost NGO (Rs.)	Capital Equipment cost FAO (Rs.)	Equip. O & M cost (Rs.)	Transport cost FAO (Rs.)	Transport cost NGO (Rs.)	Gabion Basket (Rs.)	Gabion wire (Rs.)
1	GABIONS	Rp./m3	700.50	245	35%	455.50	65%								1.00		5.90						25.0	16.00	.58	20.64
1.1	Gabion basket delivered Peshawar (2x1x1)	/m3	200.00	200																					.58	
1.2	Cost of securing wire @ 10% basket cost	/m3	20.00	20																						20.34
1.3	Delivery to Kunar @ Rp 1500/ton, 30 baskets per t, wire included	/m3	25.00	25																			25.0			
1.4	Transport to site @ Rp8/t/km assuming av. haul dist of 50 km & 35 baskets/pickup	/m3	8.00			8.00																		8.00		
1.5	Cost of final excavation @ 0.75 manday	/m3	33.75			33.75											.75									
1.6	Collection of stones assuming round trip haul of 4.0 km and Rp150/m3	/m3	245.50			245.50									1.00		1.50							25.00		
1.7	Placement of stones in basket	/m3	45.00			45.00											1.00									
1.8	Wiring of basket after filling	/m3	39.25			39.25											.85									
1.9	Backfilling around gabion/site cleaning	/m3	90.00			90.00											2.00									
2	CONCRETE WORKS (Placed) - Mass	Rp./m3	990.00	24	2%	966.13	98%	4.00			.90	.50					.75		.25	1.0	23.8	5.38	200.0	48.25		
2.1	Proportion of capital cost of mixer Rs. 36000 ,2500 hr. life & 0.8 m3/hr. output	/m3	18.00	18																	18.0					
2.2	Proportion of capital cost of vibrator @ Rs 17500, 2500 hr. life & 2.0 m3/hr. output	/m3	3.50	4																	3.5					
2.3	Proportion of capital cost of water bowser @ Rs.19000 and life of 10000 hr	/m3	2.38	2																	2.4					
2.4	Proportion of other small equipment for mixing and placement of concrete	/m3	2.00			2.00														2.0						
2.5	Running cost of mixer and vibrator considering operators and O&M cost	/m3	55.38			55.38													.25			5.38				
2.6	Cement for a mix of 1:3:6 (200 kg.)	/m3	640.00			640.00		4.00															200.0	46.90		
2.7	Aggregate cost	/m3	135.00			135.00					.90															
2.8	Sand	/m3	100.00			100.00						.50														
2.9	Placement and curing cost	/m3	33.75			33.75											.75									
3	CONCRETE WORKS (Placed) - Reinforced Base	Rp./m3	1859.33	357	19%	1502.13	81%	6.00	3.33		.90	.50				.024	2.35		.25	1.0	23.8	5.38	300.0	60.00		
3.1	Proportion of capital cost of mixer Rs. 36000 ,2500 hr. life & 0.8 m3/hr. output	/m3	18.00	18																	18.0					
3.2	Proportion of capital cost of vibrator @ Rs 17500, 2500 hr. life & 2.0 m3/hr. output	/m3	3.50	4																	3.5					
3.3	Proportion of capital cost of water bowser @ Rs.19000 and life of 10000 hr	/m3	2.38	2																	2.4					
3.4	Proportion of other small equipment for mixing and placement of concrete	/m3	2.00			2.00														2.0						
3.5	Running cost of mixer and vibrator considering operators and O&M cost	/m3	55.38			55.38													.25			5.38				
3.6	Cement for a mix of 1:2:4 (300 kg.)	/m3	960.00			960.00		6.00															300.0	60.00		
3.7	Aggregate cost	/m3	135.00			135.00					.90															
3.8	Sand	/m3	100.00			100.00						.50														
3.9	Reinforcing mesh	/m3	333.33	333					3.33																	
3.10	Shuttering (used 3 times)	/m3	144.00			144.00										.024										
3.11	Placement and curing cost	/m3	105.75			105.75											2.35									

TABLE 6.3 DIVISION OF COSTS BETWEEN FAO AND NGOs/continued

ITEM	DESCRIPTION	UNIT	RATE (Rs.)	FAO Cost (Rs.)	FAO Cost (%)	NGO Cost (Rs.)	NGO Cost (%)	Cement (bags)	Reinforcement mesh (m2)	Reinforcement bars (Kg.)	Aggregate (m3)	Sand (m3)	Stone masonry (m3)	Stone Pitch. (m3)	Stone Gabion (m3)	Timber (formwork) m3	Labour un-skilled man/day	Labour Mason man/day	Equip. Op. man/day	Capital Equipment cost NGO (Rs.)	Capital Equipment cost FAO (Rs.)	Equip. O & M cost (Rs.)	Transport cost FAO (Rs.)	Transport cost NGO (Rs.)	Gabion Basket (No.)	Gabion wire (kg)
4	CONCRETE WORKS (Precast) -Reinforced Slab	Rp./m3	2120.00	524	25%	1596.13	75%	7.00	5.00		.90	.50				.016	1.95		.35	2.0	23.3	5.38	350.0	70.00		
4.1	Proportion of capital cost of mixer Rs. 36000 ,2500 hr. life & 0.8 m3/hr. output	/m3	18.00	18																	13.8					
4.2	Proportion of capital cost of vibrator @ Rs. 17500, 2500 hr. life & 2.0 m3/hr. output	/m3	3.50	4																	5.5					
4.3	Proportion of capital cost of water bowser @ Rs.19000 and life of 10000 hr	/m3	2.38	2																	2.4					
4.4	Proportion of other small equipment for mixing and placement of concrete	/m3	2.00			2.00														2.0						
4.5	Running cost of mixer and vibrator considering operators and O&M cost	/m3	55.38			55.38													.35			5.38				
4.6	Cement for a mix of 1:2:3 (350 kg.)	/m3	1120.00			1120.00		7.00															350.0	70.00		
4.7	Aggregate cost	/m3	135.00			135.00					.90															
4.8	Sand	/m3	100.00			100.00						.50														
4.9	Reinforcing mesh	/m3	500.00	500					5.00																	
4.10	Shuttering (used 3 times)	/m3	96.00			96.00										.016										
4.11	Placement and curing cost	/m3	87.75			87.75											1.95									
5	CONCRETE WORKS (Placed) - Reinforced bars	Rp./m3	2370.00	1,792	76%	578.13	24%	7.00		36.00	.90	.50				.024	3.15		.35	2.0	23.9	5.38	350.0	70.00		
5.1	Proportion of capital cost of mixer Rs. 36000 ,2500 hr. life & 0.8 m3/hr. output	/m3	18.00	18																	18.0					
5.2	Proportion of capital cost of vibrator @ Rs. 17500, 2500 hr. life & 2.0 m3/hr. output	/m3	3.50	4																	3.5					
5.3	Proportion of capital cost of water bowser @ Rs.19000 and life of 10000 hr	/m3	2.38	2																	2.4					
5.4	Proportion of other small equipment for mixing and placement of concrete	/m3	2.00			2.00														2.0						
5.5	Running cost of mixer and vibrator considering operators and O&M cost	/m3	55.38			55.38													.35			5.38	350.0	70.00		
5.6	Cement for a mix of 1:2:3 (350 kg.)	/m3	1120.00	1,120				7.00																		
5.7	Aggregate cost	/m3	135.00			135.00					.90															
5.8	Sand	/m3	100.00			100.00						.50														
5.9	Reinforcing bars (@ 1.5% by weight)	/m3	648.00	648						36.00																
5.10	Shuttering (used 3 times)	/m3	144.00			144.00										.024										
5.11	Placement and curing cost	/m3	111.75			111.75											3.15									
6	EARTHWORKS																									
6.1	General excavation (including disposal)	Rp./m3	30.00			30.00	100%										.67									
6.2	Excavation for structures	Rp./m3	60.00			60.00	100%										1.33									
6.3	Backfill for structures	Rp./m3	30.00			30.00	100%										.67									
6.4	Trimming of canal banks to finish section	Rp./m3	7.50			7.50	100%										.17									
7	ROCK EXCAVATION																									
7.1	Excavation in hard murram inc. disposal	Rp./m3	60.00			60.00	100%										1.33									
7.2	Excavation in conglomerate	Rp./m3	75.00			75.00	100%										1.67									
7.3	Excavation in soft rock	Rp./m3	90.00			90.00	100%										2.00									
7.4	Excavation in hard rock	Rp./m3	225.00			225.00	100%										5.00									

LE 6.3 DIVISION OF COSTS BETWEEN FAO AND NGOs/continued

ITEM	DESCRIPTION	UNIT	RATE (Rp.)	FAO Cost (Rp.)	FAO Cost (%)	NGO Cost (Rp.)	NGO Cost (%)	Cement (bags)	Reinforcement mesh (m2)	Reinforcement bars (Kg.)	Aggregate (m3)	Sand (m3)	Stone masonry (m3)	Stone Pitch. (m3)	Stone Gabion (m3)	timber formwork (m3)	Labour un-skilled man/day	Labour Mason man/day	Labour Equip. Op. man/day	Capital Equipment cost NGO (Rs.)	Capital Equipment cost FAO (Rs.)	Equip. O & M cost (Rs.)	Transport cost FAO (Rs.)	Transport cost NGO (Rs.)	Gabions Basket, wire (Rs.)	(Rs.)
8	MASONRY IN WALLS OR FLOORS	Rp./m3	925.88	356	38%	569.50	62%	2.10				.39	1.20				3.00	.50	.25	2.0	20.4	4.50	105.0	21.00		
8.1	Proportion of capital cost of mixer Rs. 36000 ,2500 hr. life & 0.8 m3/hr. output	/m3	18.00	18																	18.0					
8.2	Proportion of capital cost of water bowser @ Rs.19000 and life of 10000 hr	/m3	2.38	2																	2.4					
8.3	Proportion of other small equipment for mixing and placement of concrete	/m3	2.00			2.00														2.0						
8.4	Running cost of mixer considering operators and O&M cost	/m3	54.50			54.50													.25			4.50	105.0	21.00		
8.5	Cement for a mix of 1:3	/m3	336.00	336				2.10																		
8.6	Sand	/m3	78.00			78.00						.39						.50								
8.7	Cost of mason	/m3	120.00			120.00							1.20													
8.8	Stone	/m3	180.00			180.00											3.00									
8.9	Labour for mixing and carrying	/m3	135.00			135.00																				
9	DRY STONE PITCHING	Rp./m3	390.00			390.00	100%							1.20			2.00	.50								
9.1	Stone	/m3	180.00			180.00								1.20				.50								
9.2	Cost of mason	/m3	120.00			120.00											2.00									
9.3	Labour for carrying and trimming base	/m3	90.00			90.00																				
10	GROUTED RIPRAP	Rp./m3	880.88	356	40%	524.50	60%	2.10				.39		1.20			2.00	.50	.25	2.0	20.4	4.50	105.0	21.00		
10.1	Stone	/m3	180.00			180.00								1.20				.50								
10.2	Cost of mason	/m3	120.00			120.00											2.00									
10.3	Labour for carrying and trimming base	/m3	90.00			90.00																				
10.4	Proportion of capital cost of mixer Rs. 36000 ,2500 hr. life & 0.8 m3/hr. output	/m3	18.00	18																	18.0					
10.5	Proportion of capital cost of water bowser @ Rs.19000 and life of 10000 hr	/m3	2.38	2																	2.4					
10.6	Proportion of other small equipment for mixing and placement of concrete	/m3	2.00			2.00														2.0						
10.7	Running cost of mixer considering operators and O&M cost	/m3	54.50			54.50													.25			4.50	105.0	21.00		
10.8	Cement for a mix of 1:3	/m3	336.00	336				2.10																		
10.9	Sand	/m3	78.00			78.00						.39														

for full development of the command area, some additional cleaning will be required. This is carried out at the same time as the site surveys for the structures and will only involve part of the canal systems. In most cases, during the immediate initial cleaning, the farmers will have excavated the canals to the required depth and width, but in some places where water supplies have always been a problem or where wash flows have continually damaged the canals, additional cleaning is needed. It is at these locations that design levels are most important to ensure that adequate capacity, command over the land and freeboard is maintained. Without longitudinal surveys of the canals, this is very difficult to achieve.

1.6. Stage IV - Implementation of the first structural work (Phase A) and additional site surveys

1.6.1. Phase A Structural Work

Farmers in all of the command areas supplied by the traditional informal canal systems identify locations where they feel that structures are required to overcome their problems. During Stage II, these have been given a priority rating and during the Phase A structural works, the most important and immediate sites are implemented. Although the planning process aims at a continual cycle of survey-design-implementation, in practice the work tends to revolve around the duration of the construction season and the annual budgetary allocation. It is thus more convenient to divide the structural work into two phases, the first of which comprises those essential structures and the second those structures that are needed but could be deleted or deferred if sufficient funds are not available.

Under this Stage of the rehabilitation process, the plans and designs prepared for structural improvements during the earlier Stages are implemented according to the drawings, specifications and work plans prepared by the design Engineers.

Experience from the FAO rehabilitation programmes has shown that NGOs who engage Afghan Engineers and site technicians provide the most suitable implementing partners. These should be selected either from those NGOs who have already successfully completed similar works to the required standard or from those NGOs who have indicated that they have the capability for executing such works, have the required staff and also maintain good relations with the individual beneficiary communities.

Each NGO is required to engage suitably experienced professional staff who will plan the construction activities and supervise the works. Before agreements are signed with the NGOs, they need to satisfy the donor programme coordinator that they have the appropriate qualified engineering staff to carry out the work and can provide the required effective support for their field activities. The site Engineer will act as team leader for the duration of the works and he will be guided and supervised by experienced Engineers from the head quarters of the NGO in Afghanistan. They are required to visit the works site at regular intervals and for at least 7 days in every month.

TABLE 6.4 UNIT COSTS FOR IRRIGATION CONSTRUCTION WORKS

ITEM	DESCRIPTION	UNIT	RATE (Rp.)
1	EARTHWORKS		
1.1	General excavation including disposal	m^3	30.00
1.2	Excavation for structures	m^3	60.00
1.3	Backfill for structures	m^3	30.00
1.4	Trimming of canal banks to finished section	m^2	7.50
2	ROCK EXCAVATION		
2.1	Excavation in hard Murram incl. disposal	m^3	60.00
2.2	Excavation in conglomerate	m^3	75.00
2.3	Excavation in soft rock	m^3	90.00
2.4	Excavation in hard rock	m^3	225.00
3	CONCRETE WORKS (Placed)		
3.1	Mass Concrete	m^3	990.00
3.2	Mesh reinforced PC300 Concrete	m^3	1860.00
3.3	Mesh reinforced PC350 Concrete	m^3	2120.00
3.4	Bar reinforced PC350 Concrete	m^3	2370.00
4	MASONRY WORKS		
4.1	Masonry in walls or floors	m^3	925.00
4.2	Grouted RipRap	m^3	831.00
4.3	Dry Stone Pitching	m^2	320.00
5	GABIONS		
5.1	Gabion basket placed and filled (2m*1m*.5m)	m^3	
5.2	Gabion basket placed and filled (2m*1m*1m)	m^3	700.00
5.3	Gabion basket placed and filled (5m*3m*.3m)	m^3	
6	OTHER ITEMS		
6.1	Timber for stop logs	m^3	6000.00
6.2	[illegible]	m^2	[illegible]

TABLE 6.5 STANDARD FORM FOR COSTING OF STRUCTURES

CANAL: STRUCTURE:

ITEM	DESCRIPTION	UNIT	RATE	QTY	COST	Cement	Reinforcement mesh	Reinforcement bars	Aggregate	Sand	Stone masonry	Stone Pitch.	Stone Gabion	timber formwork/other	Labour unskilled	Labour Mason	Equip. Op.	Capital Equipment cost NGO	Capital Equipment cost FAO	Equip. O & M cost	Transport cost FAO	Transport cost NGO	Gabions Basket	Gabions wire
			(Rs.)		(Rs.)	(bags)	(m2)	(kg.)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	man/day	man/day	man/day	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(No.)	(Rs.)
1	EARTHWORKS																							
1.1	General excavation including disposal	m3	30.0																					
1.2	Excavation for structures	m3	60.0																					
1.3	Backfill for structures	m3	30.0																					
1.4	Trimming of canal banks to finished section	m2	7.5																					
2	ROCK EXCAVATION																							
2.1	Excavation in hard Morram incl. disposal	m3	60.0																					
2.2	Excavation in conglomerate	m3	75.0																					
2.3	Excavation in soft rock	m3	90.0																					
2.4	Excavation in hard rock	m3	125.0																					
3	CONCRETE WORKS (Placed)																							
3.1	Mass Concrete	m3	990.0																					
3.2	Mesh reinforced PC300 Concrete	m3	1860.0																					
3.3	Mesh reinforced PC350 Concrete	m3	1120.0																					
3.4	Bar reinforced PC350 Concrete	m3	1310.0																					
4	MASONRY WORKS																							
4.1	Masonry in walls or floors	m3	926.0																					
4.2	Grouted RipRap	m3	881.0																					
4.3	Dry Stone Pitching	m3	390.0																					
5	GABIONS																							
5.1	Gabion basket placed and filled (2m*1m*.5m)	m3																						
5.2	Gabion basket placed and filled (2m*1m*1m)	m3	700.0																					
5.3	Gabion basket placed and filled (6m*1m*.3m)	m3																						
6	OTHER ITEMS																							
6.1	Timber for stop logs	m3	6000.0																					
6.2		m3																						
6	TOTAL BASE COST OF STRUCTURE																							
	Supervision @ 10%																							
	Contingencies @ 10%																							
7	TOTAL COST OF STRUCTURE																							
	Cost to FAO					x	x	x											x		x		x	x
	Cost to NGO								x	x	x	x	x	x	x	x	x	x		x		x		

Note: x indicates items included in respective costs

TABLE 6.6

Item	Description	Unit	Rate	Quantity	Total Cost
1	Supervision Staff				
	Supervising Engineer (Peshawar)	mm	7,000	.25	1,750
	Site Construction Engineer	mm	6,000	1.00	6,000
	Assistant Engineer/Foreman	mm	2,500	1.00	2,500
2	Field Allowance				
	Supervising Engineer (Peshawar)	day	100	7.50	750
	Site Construction Engineer	day	100	30.00	3,000
	Assistant Engineer/Foreman	day	100	30.00	3,000
3	Site Camp				
	Storeman/Guard	day	60	60.00	3,600
4	Transport				
	Vehicle Hire Inclusive	month	12,000	1.00	12,000
	Total				32,600

Notes:

(a) For Kunar Province, Hire rates for vehicle is reduced to Rs.10000.
(b) Field office/accommodation provided free by the beneficiary villagers.
(c) Where NGO requires a store in Khost, an additional rental allowance of Rs.1500 can be paid if agreed with FAO in advance.
(d) Where NGO does not provide meal allowance, but a cook and food etc., no additional allowances will be paid as the sums above are adequate to cover this arrangement.

(e) For site surveys, different costs apply.

TABLE 6.7

Item	Description	Unit	Rate	Quantity	Total Cost
1	Supervision Staff				
	Supervising Engineer (Peshawar)	mm	7,000	.50	3,500
	Chief Surveyor	mm	6,000	1.00	6,000
	Assistant Surveyor	mm	4,000	1.00	4,000
	Chairman/Rodman	mm	2,500	2.00	5,000
	Labourers	Day	50	60.00	3,000
2	Field Allowance				
	Supervising Engineer (Peshawar)	day	100	15.00	1,500
	Site Construction Engineer	day	100	30.00	3,000
	Assistant Surveyor	day	100	30.00	3,000
	Chairman/Rodman	day	100	60.00	6,000
3	Site Camp				
	Storeman/Guard	day	60	60.00	3,600
4	Transport				
	Vehicle Hire Inclusive	month	15,000	1.00	15,000
	Total				53,600

Notes:

(a) Field office/accommodation provided free by the beneficiary villagers.

(b) Where NGO is unable to obtain suitable accommodation, an additional rental allowance of Rs.1500 can be paid if agreed with FAO in advance.

(c) Where NGO does not provide meal allowance, but a cook and food etc., no additional allowance will be paid as the sums above are adequate to cover this arrangement.

(d) Additional Labourers will be provided free by the beneficiaries.

(e) For surveys of less than one month, the above rates will be used on a pro rata basis with one day added for travel in each direction.

(f) For construction supervision, different costs apply.

TABLE 6.8

Item	Description	Unit	Rate	Quantity	Total Cost
1	Supervision Staff				
	Supervising Engineer (Peshawar)	mm	7,000	.25	1,750
	Chief Surveyor	mm	6,000	1.00	6,000
	Assistant Surveyor	mm	4,000	1.00	4,000
	Chairman/Rodman	mm	2,500	2.00	2,500
	Labourers	Day	50	60.00	3,000
2	Field Allowance				
	Supervising Engineer (Peshawar)	day	100	7.50	750
	Site Construction Engineer	day	100	30.00	3,000
	Assistant Surveyor	day	100	30.00	3,000
	Chairman/Rodman	day	100	30.00	3,000
3	Site Camp				
	Storeman/Guard	day	60	60.00	3,600
4	Transport				
	Vehicle Hire Inclusive	month	12,000	1.00	12,000
	Total				42,600

Notes:

(a) Field office/accommodation provided free by the beneficiary villagers.

(b) Where NGO is unable to obtain suitable accommodation, an additional rental allowance of Rs.1500 can be paid if agreed with FAO in advance.

(c) Where NGO does not provide meal allowance, but a cook and food etc., no additional allowance will be paid as the sums above are adequate to cover this arrangement.

(d) Additional Labourers will be provided free by the beneficiaries.

(e) For surveys of less than one month, the above rates will be used on a pro rata basis with one day added for travel in each direction.

(f) For canal surveys and construction supervision, different costs apply.

TABLE 6.9

Item	Description	Unit	Rate	Quantity	Total Cost
1	Design Office Staff				
	Supervising Engineer (Peshawar)	mm	7,000	.50	3,500
	Chief Surveyor	mm	6,000	1.00	6,000
	Assistant Surveyor	mm	4,000	2.00	8,000
	Draftsman	mm	3,500	2.00	7,000
2	Office Materials				
	Drafting Materials	LS	3,000	1.00	3,000
	Reporting	LS	2,050	1.00	2,050
	Report Materials (films etc)	LS	2,400	1.00	2,400
3	Office Overhead				
	Contribution to Overhead @ 33%	LS	10,639	1.00	10,639
	Total				42,590

Notes:

(a) Includes all necessary materials for reporting according to agreed FAO standards.

(b) Average draftsman can complete 2.5 km of canal longitudinal survey per working day

(c) On average, time allocated for office plotting etc. is equal to the actual time spent on field survey.

FIGURE 6.1 CLEANING AND SURVEY COST

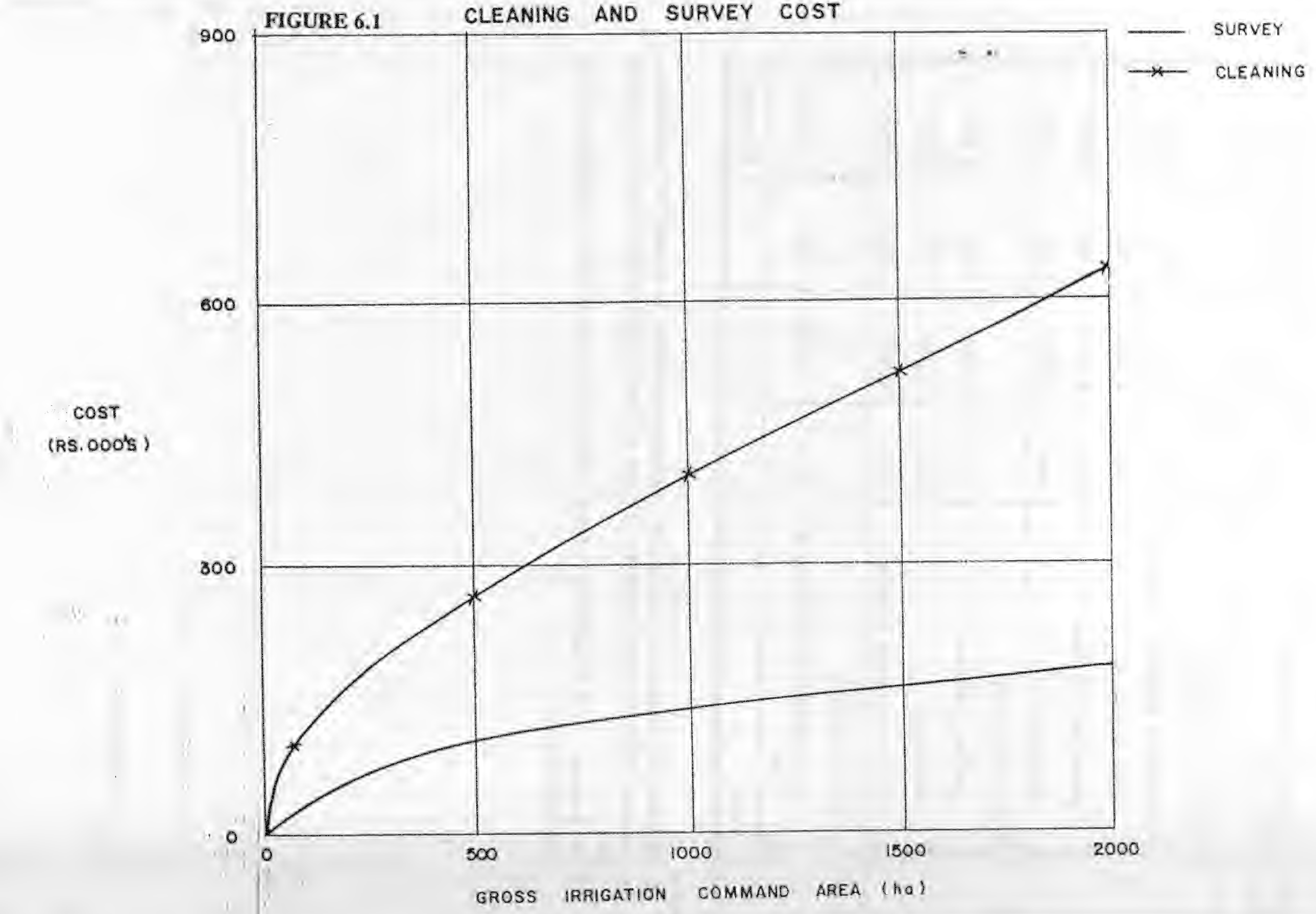


FIGURE 6.2 COSTS OF INTAKE STRUCTURES

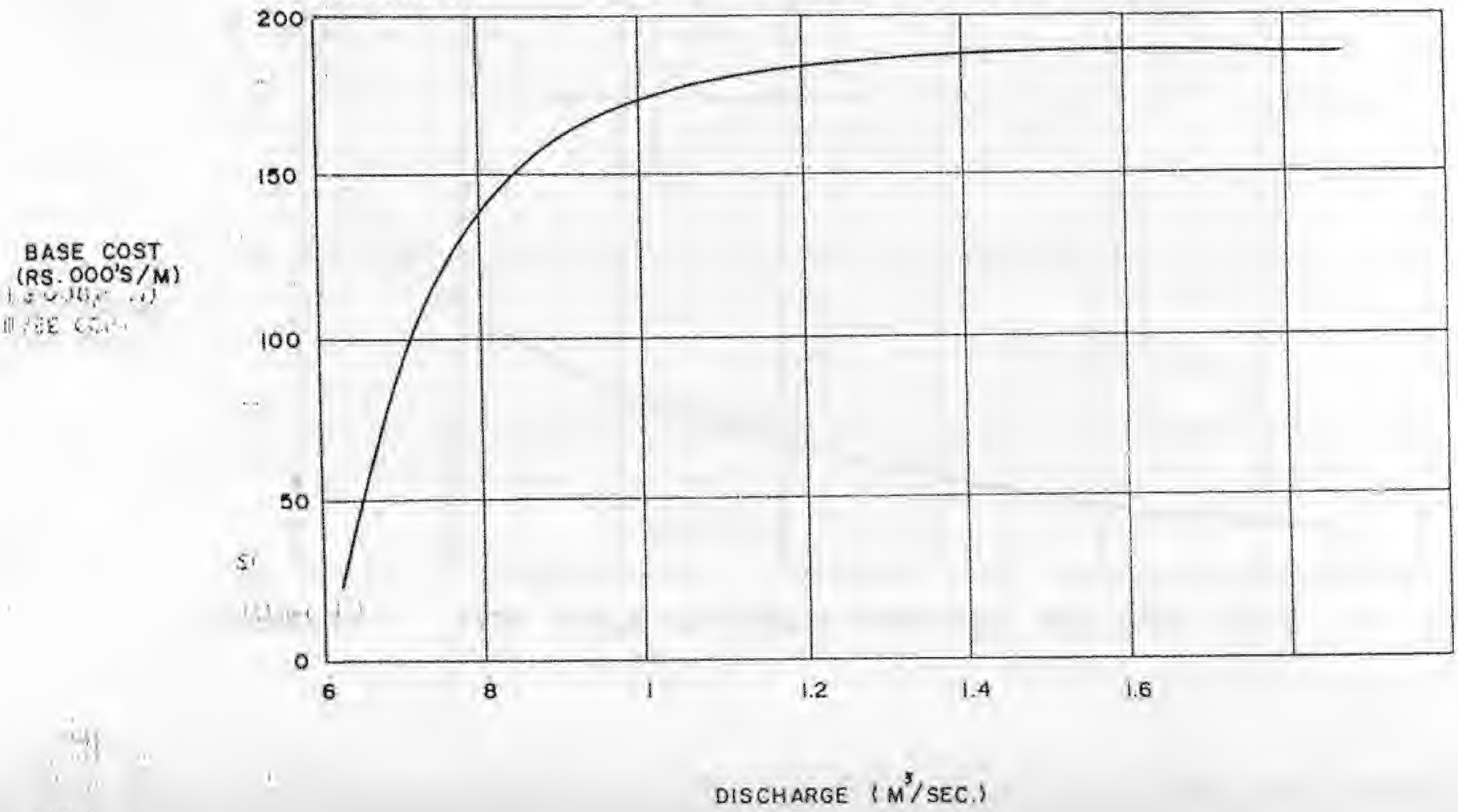


FIGURE 6.3 BASE COSTS OF CULVERT STRUCTURE WITH GUIDE WALLS

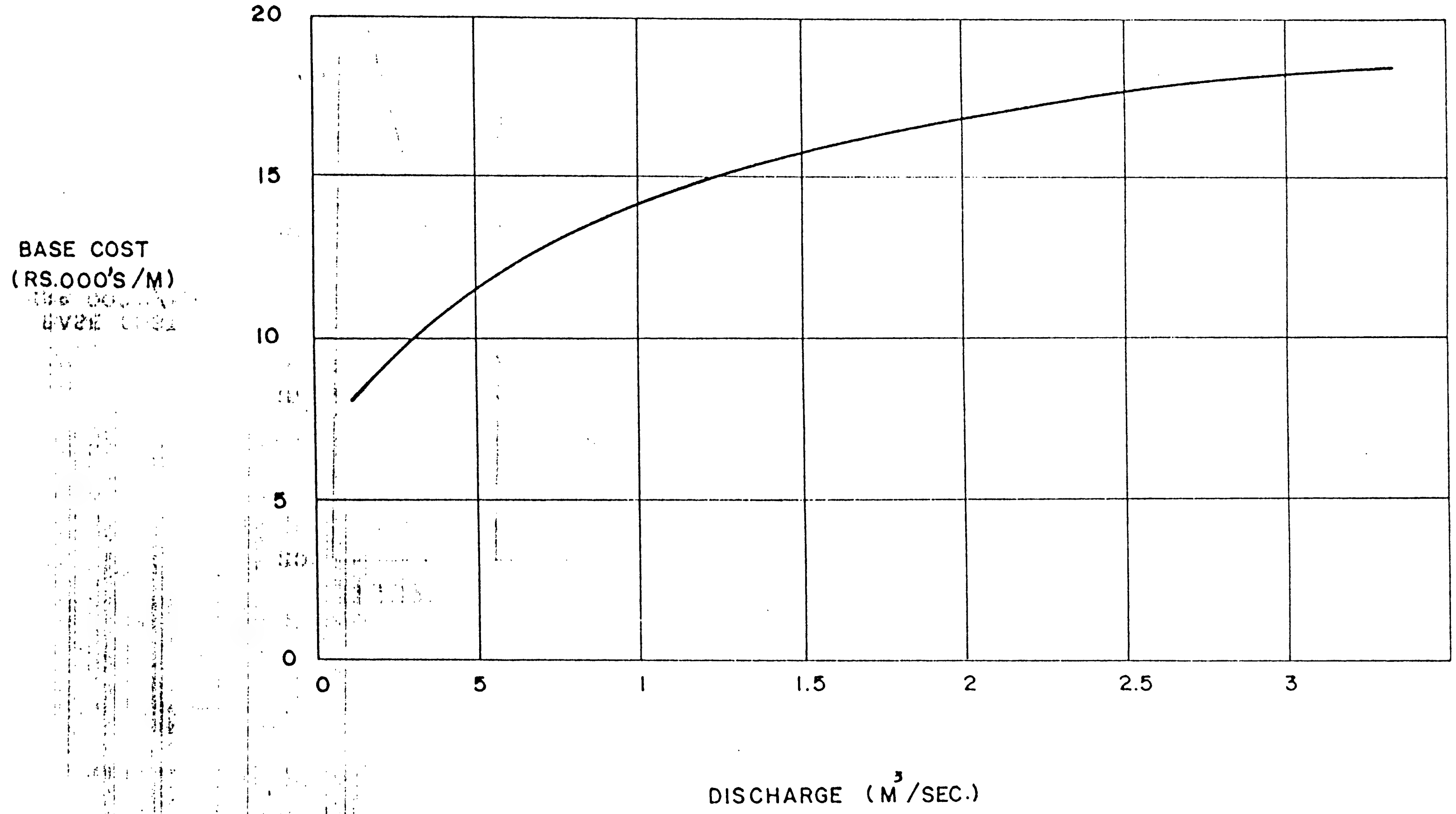
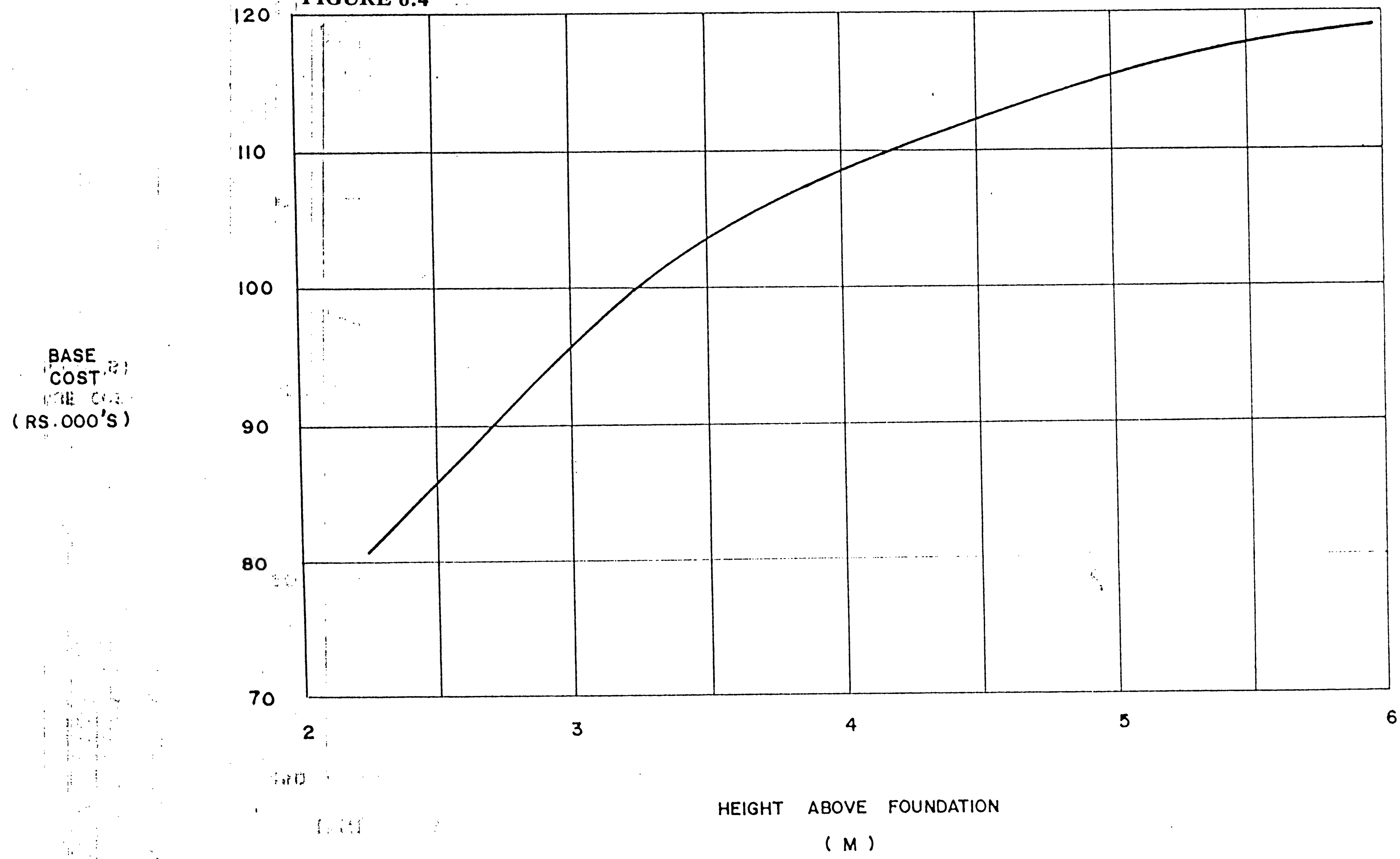


FIGURE 6.4

COSTS OF ELEVATED FLUME STRUCTURES



Regular monthly reports need to be provided by each NGO to the Donor Engineer on the progress of the works. Any problems or delays that may affect the ultimate objective of the project must be brought immediately to the attention of the Engineer. The NGO will employ sufficient skilled and unskilled staff and mobilize all the necessary resources to ensure that the works are completed to the highest standard and within the planned time scale.

1.6.2. Monitoring and follow-up

To ensure that the construction agreements are executed as planned and to the required standard, technical guidance must be given to the NGOs by the donor in a similar way to that provided by FAO. In many cases particular attention has to be paid to the location of the structures, elevations of foundations and construction techniques. Regular monitoring and follow up during construction will ensure that errors are identified before they become costly and that the site staff can be given in-service training through the transfer of technology.

1.6.3. Surveys and designs for Phase B Structures

Whilst construction is being carried out on a number of sites under Phase A, additional planning is taking place for the next stage of construction (Phase B). This will follow exactly the same process as for the Phase A structures and topographical site surveys followed by structure selection and detailed design for those sites where new structures are required.

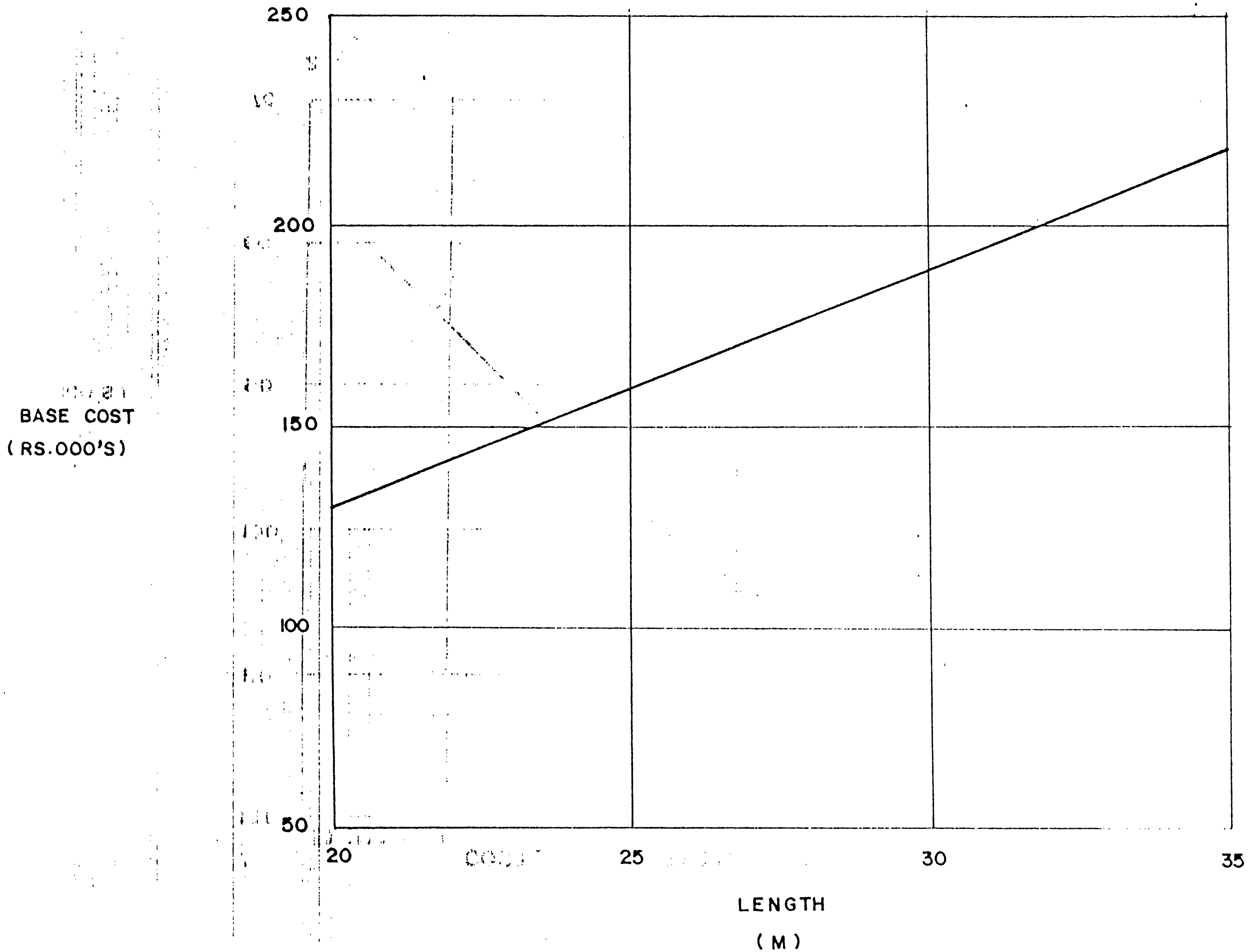
Again the designs will involve the standard structures adapted to the particular site conditions and linked in with the canal design prepared under Stage II, with the draft designs being field checked and finalized in advance of construction planning and final costing.

1.7. Stage V - Phase B of the structural work.

This Stage will generally follow on from the completion of Phase A, however, where delays in construction have been experienced and additional funds are available, it is quite likely that there will be some overlap of Stages IV and V. The activities, conditions and requirements will be exactly the same as for the Phase A.

FIGURE 6.5

COSTS OF BANK PROTECTION WORKS



7. CONSTRUCTION PLANNING

7.1. Design of Structures

Although the NGOs have some design capability, it was decided at the start of the FAO Programme that, to save time and to ensure standardization of designs, the FAO project office would produce designs and drawings for each of the structures to be built. Because of the large number of structures to be designed, a range of structures was selected to represent each of the major types to be constructed under the programme. These detailed standard designs have then be used for other similar sites, adapting them for the local topographical conditions and different design discharges.

7.2. Construction Drawings

For the presentation of the designs, standard drawings sizes and details were established. A reference list for the projects were set up (see Appendix 1) and these have been used on all drawings and cost tables. Plans and sections have been produced at scales of either 1:100, 1:50, or 1:25. Details at a scale of 1:10 are also shown. Site plans at 1:500 give the general layout of the works.

In most cases the A1 drawing size has been adopted for convenience. As the structures are not complicated and are quite small, the details are adequately presented at the given scales. At least one drawing should be produced for each structure.

7.3. Construction Materials and Equipment

Experience gained from the first construction works to be carried out by NGOs under other programmes, has shown that the supply of materials and equipment from outside the Province can be subjected to many delays beyond the control of the NGOs. These activities thus lie on the critical path during construction. Because of the recognized role that UN/FAO is playing in the reconstruction of Afghanistan, many of these delays can be avoided or reduced. It was therefore decided that FAO should purchase all materials not available within the Province and supply them to a store set up for the project. The NGOs will draw the materials that they require on a monthly basis and similarly, FAO will restock the store once a month.

7.4. Construction Plans

The works that were planned for the Kunar programme have been used to illustrate the approach to be adopted for construction planning. The timing of the construction of different types of work was determined considering all of the constituent items such as site clearing, collection of material, excavation and masonry work. These have been linked to the overall construction plan for the whole works. The programme for each structure has been finalized considering the type and location of the structure and the permissible construction season considering local conditions (climate and river flow

conditions). In Table 7.1, the periods during which each type of structure can be built in the Lower Kunar Basin is illustrated.

A critical path programme was used to prepare the phased plan for construction work and the results are given in Table 7.2. From the estimated start and completion dates for all structures that is given in Table 7.2, it can be seen that the first eight structures were due to be started at the end of July 1991 and all works completed by the end of September 1992. Some delays were experienced due to security problems, but most of the structures were completed within three months of the planned date.

7.5. Standard Agreement

An example of the standard agreement for the construction of the structures is shown in Appendix 2. In addition to the FAO Letter of Agreement, the agreement comprises the Terms of the Agreement, General Technical Specifications, Cost Estimate, Work Plan and Detailed Drawing. A separate agreement should be drawn up for each structure. All those NGOs who are to undertake the construction works are required to provide a full list of the staff who will work on the project, both permanent and part time, their associated costs and any additional equipment that they wish to use or purchase. The NGOs are also required to agree to complete the works for the sum provided, **without cost over runs or time delays**, unless adverse site conditions or other problems, such as security, prevent them keeping to the agreed schedules. In the event of any cost claims, full details of the claim and the reasons for it must be provided prior to agreement of additional payments. Any additional work that is requested by FAO to be carried out at the same site will be paid for at the same rates agreed under the original contract.

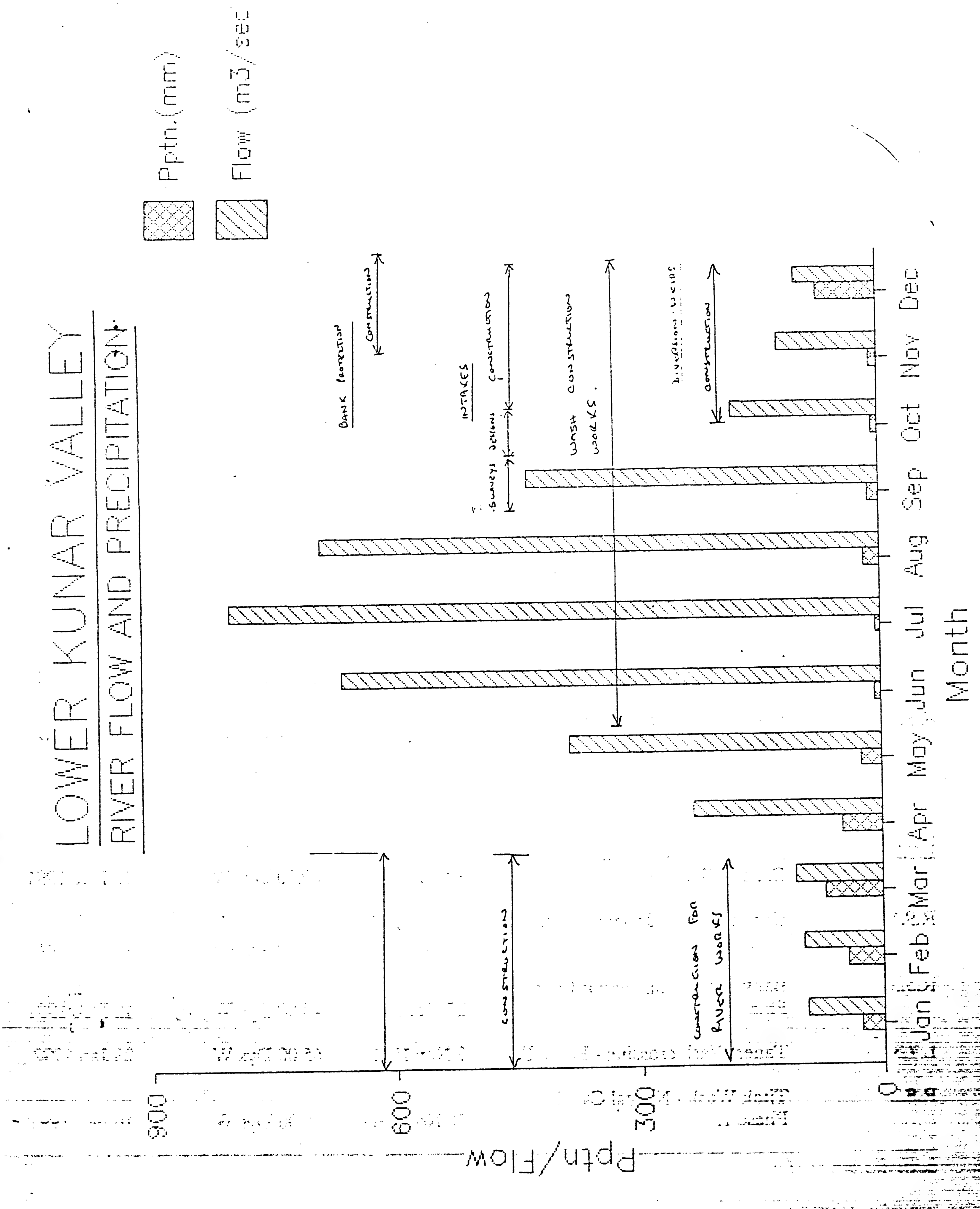

LOWER KUNAR VALLEY
RIVER FLOW AND PRECIPITATION
Pptn.(mm)
Flow (m3/sec
Pptn/Flow
0
300
600
900
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
BANK PROTECTION
CONSTRUCTION
INTAKES
SURVEYS DESIGNS
CONSTRUCTION
WASH CONSTRUCTION
WORKS.
DIVERSION WEIRS
CONSTRUCTION
CONSTRUCTION FOR
RIVER WORKS

TABLE 7.2

CONSTRUCTION PLAN FOR STRUCTURES

Task & Milestone List

Task Name	Description	Start date	Planned duration	Finish date
Start		26 Jun 1991		26 Jun 1991
L.8.3(a)	Khyber Wash Crossing - Culvert Phase I	26 Jun 1991	50.00 Dys W	26 Aug 1991
R.10.1	Intake - Shonoor Canal Phase I	26 Jun 1991	40.00 Dys W	13 Aug 1991
R.5.5	Babur Wash Crossing - Phase I	26 Jun 1991	60.00 Dys W	7 Sep 1991
R.8.3	Patan Wash Flume - Nurgal Canal - Phase I	26 Jun 1991	60.00 Dys W	7 Sep 1991
R.8.4	Chinar Wash - Nurgal Canal Phase I	14 Jul 1991	60.00 Dys W	26 Sep 1991
R.9.3	Mea Qala Flume - Jengally Canal - Phase I	3 Aug 1991	60.00 Dys W	14 Oct 1991
R.5.6	Diwagal Wash Crossing - Phase I	15 Aug 1991	60.00 Dys W	26 Oct 1991
L.8.3(b)	Khyber Wash Crossing - Weir Phase I	27 Aug 1991	60.00 Dys W	6 Nov 1991
R.8.7	Mazar Dara Wash - Nurgal Canal - Phase II	28 Sep 1991	55.00 Dys W	1 Dec 1991
L.7.2	Shikoray Wash Improvements Phase II	3 Oct 1991	50.00 Dys W	1 Dec 1991
L.8.2	Bank Protection, Khas Kunar Canal - Phase II	3 Oct 1991	60.00 Dys W	12 Dec 1991
R.9.1	Upper intake - Jengally Canal Phase II	15 Oct 1991	40.00 Dys W	1 Dec 1991
R.5.3	Bank Protection, Babur Canal Phase II	27 Oct 1991	40.00 Dys W	12 Dec 1991
L.7.3	Taner Wash crossing - Phase II	7 Nov 1991	65.00 Dys W	23 Jan 1992
R.8.2	Titak Wash - Nurgal Canal Phase II	20 Nov 1991	70.00 Dys W	10 Feb 1992

8. REPORTING

8.1. Introduction

Unless otherwise stated, no separate payments are made for preparation of all documents, long sections, plans, correspondence, returns, reports, photographs etc., to be prepared by the NGO and submitted in accordance with the provisions of the agreement. The NGO is required to provide brief reports supported by photographs of the various stages of the survey and construction works, particularly those relating to approval of the works. The requirements for reporting are that, even for interim payments, adequate information must be presented to show what work has been carried out since the last payment. The minimum requirements for the Reports are set out below:

8.2. Requirements on Signature of Agreement

On signature, the NGOs must go through the design drawings in detail with the Engineers to ensure that they fully understand what has to be built, where it is exactly located and what are the design levels for all components. The work plan must be closely reviewed so that the NGO closely follows it and that the times for critical inspection can be identified. If the NGOs identify inconsistencies or problems with the designs during setting out or construction, they must bring these immediately to the attention in writing to the Design Engineers. Variations are only be paid if they have been recorded in writing and agreed with the Design Engineers before they are started. This is written into all agreements.

8.3. Variations during Construction

Although there has to be a certain degree of flexibility in implementation, the number of variations made by the NGOs without recourse to the design Engineers has to be kept to an absolute minimum and certainly should not involve significant technical modifications or large cost overruns. If there are differences between designs and what has been implemented then these must be well documented and reported to the funding agency. If the NGOs cannot produce written records signed by the Engineers agreeing to site modifications, they are not paid and where the results are unsatisfactory, the NGO is required to redo the work at their own cost.

8.4. Progress Reporting

Each agreement has a reporting and payment schedule which are related. These must be complied with by the NGO as they are another means of checking the progress and accuracy of the work. For each payment, photos must be produced together with copies of the design drawings coloured to show what work has been completed and what is in progress. Five colours must be used:

Not started	-	Blank
25 % Complete	-	Orange
50 % Complete	-	Green
75 % Complete	-	Yellow
100% Complete	-	Blue

Photographic records of the structural works completed by the NGOs must cover each stage of the work and the main features of the agreements in sufficient detail, as set out in the reporting requirements. The photos must show each component of the work as given on the drawings.

The Design/Supervising Engineers from the Donor agency are often unable to visit site at the times required by the NGOs. The reporting requirements are aimed at enabling the donor agency to make payments to the NGO under such situations. In the absence of site visits by the Donor Engineering staff, it is the responsibility of the NGO to ensure that they produce sufficient detailed evidence on which the Donor can agree that the progress has been made and the drawings and specifications have been complied with.

8.4.1. Interim Reports

(a) Copies of photographs showing the work that has been carried out to date and the status of the works at the time of the payment request.

(b) List of dates when work started on site and when it was stopped due to insecurity or other problems beyond their control.

(c) Brief report presenting the:

- (i) status of the works to date,
- (ii) problems that have been experienced,
- (iii) estimate by the NGO of the overall amount of works completed,
- (iv) plan with dates for completion of the work,
- (v) draft copies of long sections, cross sections, survey plans and survey books for the canal surveyed for checking and agreeing with FAO.

8.4.2. Final Report

This must be submitted prior to the release of the final payment and must be completed to an acceptable standard.

(a) Full report presenting a summary of the work carried out from start to finish. This should include:

(i) Photographs showing all stages of the work, presenting a complete idea of the works carried out and to enable a careful assessment to be made of the structural aspects of the works.

(ii) Description of how the work was undertaken, staff employed, equipment and materials used by NGO and supplied also by FAO, etc.

(iii) Problems encountered during the work and dates when no work was possible due to insecurity or other problems beyond their control.

(iv) Summary of payments made to NGO and when.

(b) Full financial report for the project period.

9. DRAINAGE

9.1. Introduction

In some areas, the internal natural drainage systems are inadequate to drain away the excess precipitation or irrigation water from the irrigated lands. In many areas, there is sufficient natural slope that the canals of the lower systems act as drains for the upper systems. However there are some places in all command areas where internal drainage is poor and the natural outlet is blocked for one reason or other. The low lying lands, particularly those located near to the rivers are the most badly affected.

The objectives of the drainage systems is to collect the water in excess of requirements and to discharge it into the river or seasonal streams to thereby minimize the productivity losses due to inundation. In almost all sites in Afghanistan, gravity drainage systems have been used in the past and are adequate to cope with most problems encountered provided that the systems are correctly designed and these are based on sufficient topographical data on slopes and command levels.

In all of the areas where the FAO programmes have been working, there have been only minor instances of drainage problems. Most of these can or will be solved through the construction of appropriately located drainage channels. In few of the traditional irrigation systems is drainage a major constraint. This is not however the case in the newer more formal systems that have been developed in the Southern parts of Afghanistan in the Helmand Valley.

The contents of this chapter are thus aimed at presenting the basic considerations for drainage design should a problem be experienced. It is by no means comprehensive and will require further development.

9.2. Design Volumes and Rates

The potential loss in productivity due to inundation of crops will determine the design capacity of drains. Yield reduction occurs if the period of inundation is more than 24 hours and the actual damage that occurs will depend upon the crop grown. The criteria used for design is that once in 5 years, a rainfall intensity over 1-3 days will exceed the capacity of the drain. In other words, the drainage system is designed to remove the 3 day accumulated rainfall, with a 20 % frequency, from the irrigated land in between 24 and 72 hours depending on the crop grown.

In practice in Afghanistan, most drainage systems are designed to control water table levels rather than to handle high rainfall intensities. Selection of drainage rates will therefore not be the dominant factor in drain design. Spacing and size of drains will in most cases depend upon the permeability of the soils to be drained.

9.3. Drainage Discharge

In principle the water drained during any period can be calculated as follows :

$$D = R + I - Cu - S$$

Where :

D	=	Surface drainage runoff
R	=	Rainfall in the same period
I	=	Irrigation supply
Cu	=	Consumptive use of crop
S	=	Storage differential, that is difference in water depth on the fields in the period considered

Since consumptive use of crop is practically equal to irrigation supply and excess water is expected to be disposed of with base flow, which means it must be drained in N days, where N is the duration of the rainfall.

The drainage capacity for the area considered is calculated with the general formula :

$$Q = C \times f \times (A/1000)$$

Where :

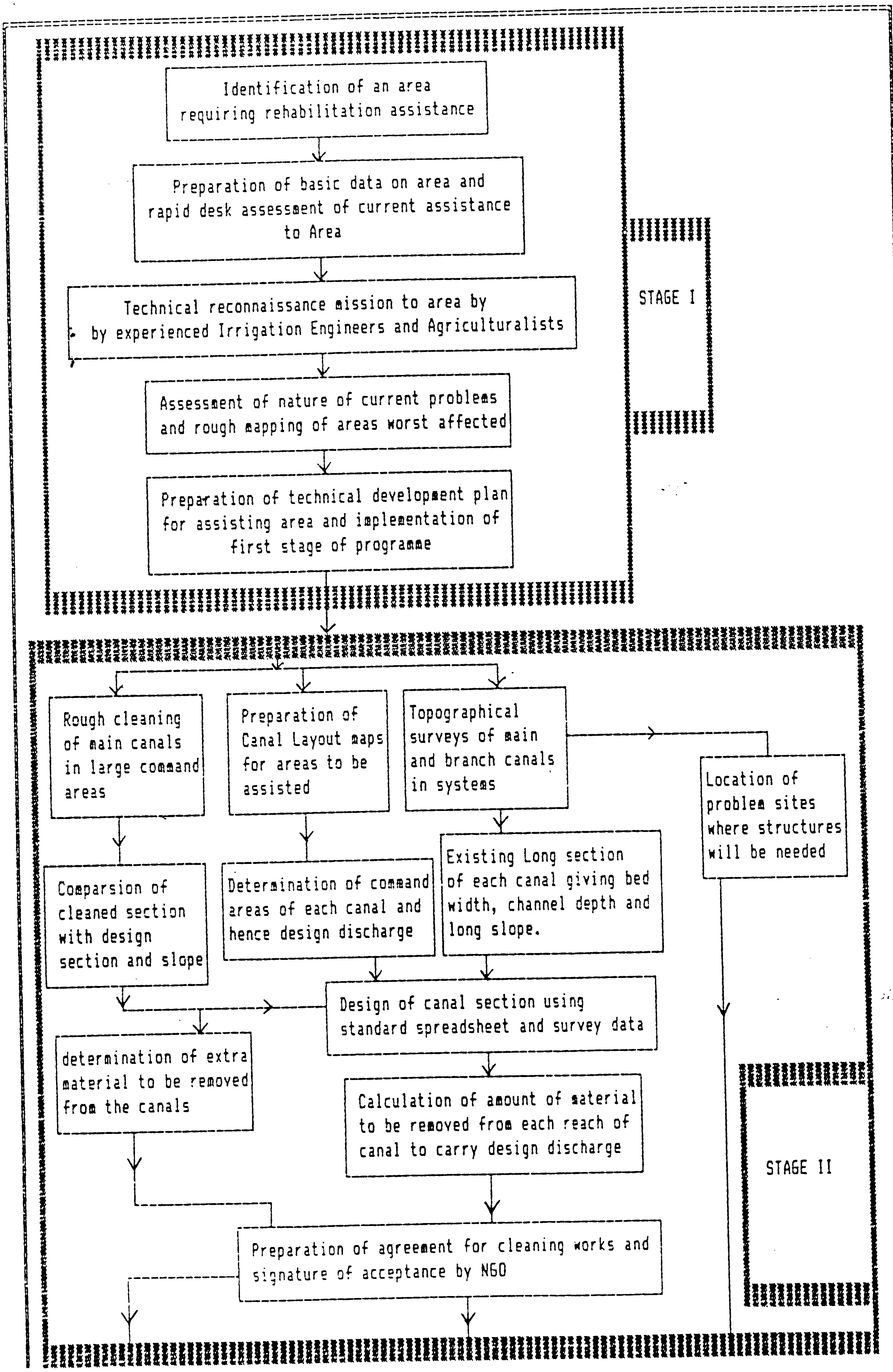
Q	=	Required capacity of channel in m^3/s
C	=	Rn/8.64 N = Drainage coefficient
A	=	Drainage area in ha
Rn	=	Rainfall amount in the duration T years in mm
N	=	Duration of rainfall in days
f	=	reduction factor of drainage area,
	=	1.0 - 0.153 (log A - log 400)

The area/reduction factor "f" is a diversity factor applied to drainage areas larger than 400 ha. This factor accounts for the fact that the full rainfall intensity is not likely to occur simultaneously over the entire area, particularly as the area becomes larger.

Example for Drainage Coefficient Calculation :

R(n)t	=	174 mm for 3 day consecutive rainfall intensity with a return period of 5 years,
IR	=	0, irrigation is stopped

TABLE 1.1 REHABILITATION PROCESS



ET = 5 mm/day
P = 2 mm/day
S = 5 mm/day

Using the formula:

$$D(n) = R(n)t + n\,(IR - ET - P) - S$$

The surface drainage run off over 3 days is computed as

$$D(3) = 174 - 3\,(5+2+5)$$
$$= 138 \text{ mm/day}$$

Drainage coefficient:

$$D = 138/3 \times 8.64$$
$$= 5.32$$
$$\text{say } D = 5 \text{ l/s/ha}$$

This example is provided to illustrate the process and in fact the drainage rate that derives would be on the high side for most of Afghanistan.

9.4. Design of Drainage Channels

Drainage channels are designed using the Manning-Strikler formula in the same way as for irrigation channels.

$$V = \frac{R^{2/3} \times S^{1.2}}{n}$$

or $$V = K \times R^{2/3} \times S^{1.2}$$

Where,

V = Velocity
R = Hydraulic radius
n = Roughness factor
S = Slope

9.5. Strickler Roughness Coefficient

As drains are not constantly flowing full, vegetation grows easily and causes reduction in the value of "K" (or an increase in roughness and hence the value of "n"). Suggested "K" values are given below:

Water Depth (m)	K in $m^{1/3}/s$
$h < 1.0$	25
$1.0 < h < 1.5$	30
$1.5 < h < 2.0$	32.5
$2.0 < h < 2.5$	35
$2.5 < h$	40

9.6. Cross Section

The bottom width to water depth ratio ($n = b/h$) for smaller drains is taken between 1 and 3. For the larger drains the value of this ratio should be at least 3. The minimum bottom width adopted is 0.60 m for drains and the minimum side slopes in the various soil materials are suggested as follows:

Excavation Depth D in m	Minimum Side Slope 1 horizontal : m vertical
$D < 1.0$	1.0
$1.0 < D < 2.0$	1.5
$D > 2.0$	2.0

Flatter side slopes are sometimes required where strong seepage inflow into the drain is expected.

9.7. Minimum/Maximum Slopes

The determination of the maximum allowable velocity in the drains in cohesive materials is similar as for irrigation canals. For construction the basic maximum allowable velocity used in design is 0.6 m/s for non-cohesive soils, and 1.2 m/s in cohesive soils. This will of course be affected by the protection afforded by vegetation and velocities considerably in excess can be tolerated if drains flow intermittently. A guide to theoretical maximum allowable velocity used in design for different soils is given below:

Soil Characteristic	Maximum Velocity (m/sec.)	Soil Characteristic	Maximum Velocity (m/sec.)
Sandy silt	0.45	Loam Clay	0.9
Sandy loam	0.60	Clay	1.2
Loam	0.75	Sandy Clay	1.5

To avoid silt deposition problems, a minimum velocity is used to design the drainage channel. Suggested values are given below:

Water depth m	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Velocity (m/s)	0.19	0.3	0.38	0.45	0.56	0.65	0.69	0.70	0.77	0.82

9.8. Minimum Curves in the Drainage Channels

The minimum radius of curvature as measured on the center line of drain should not be less than 5 metres. Suggested values are:

Q Design in m^3/s	Minimum Radius in m
Q < 5.0	3 x bottom width
5 < Q < = 7.5	4 x bottom width
7.5 < Q < = 10.0	5 x bottom width
10 < Q < = 15.0	6 x bottom width
Q > 15.0	7 x bottom width

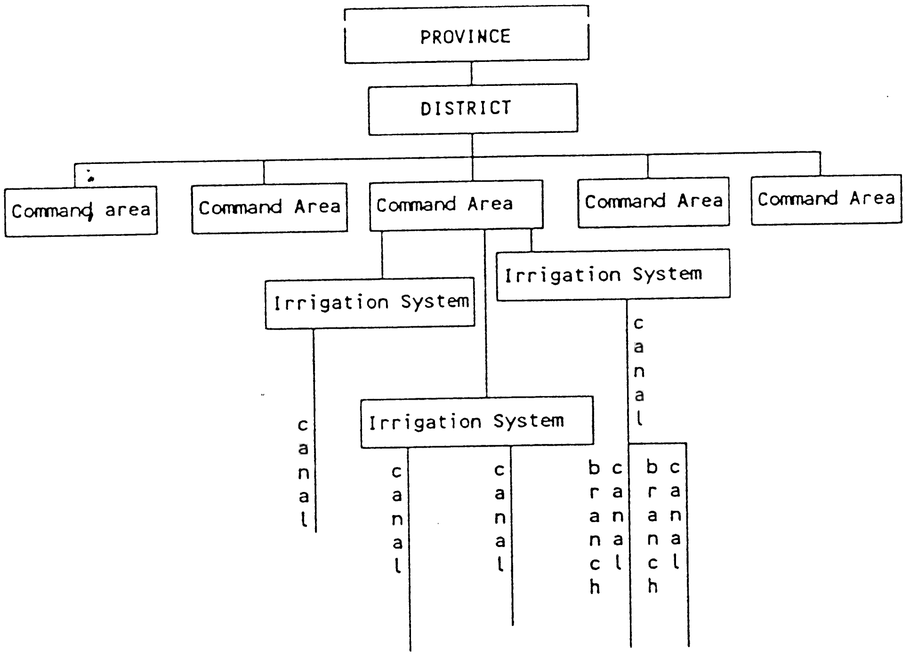
The minimum radius applied for unlined drains was 5 m.
If a smaller radius is required due to land acquisition and other problems, the radius can be reduced to 3 x the bottom width. This may require lining of the outer curve of the drain.

APPENDIX 1

REFERENCE LIST FOR PROJECTS

A.1.1. INTRODUCTION

In the fourth report of the FAO Irrigation Consultant[1], a reference list for the projects to be assisted in the Eastern Paktia Province was suggested. This has now been finalized for use on all the engineering projects to be undertaken with FAO assistance. It is based first on the Province, then on the command area, the irrigation system, the irrigation canal and finally on the structure concerned.



A.1.2. Provinces Supported by FAO Programme (Irrigation Component)

At present only two provinces are covered by the Programme, but it is expected to be extended to Kandahar and Nangarhar. The following will thus be used:

PROVINCE	SYMBOL
Kunar	KU
Eastern Paktia	P
Kandahar	KAN
Nangarhar	NAN

1 Anderson, Ian. McA., Report on fourth Technical Assistance Mission, Programme for the Rehabilitation of Afghanistan Agriculture, Agrisystems (Overseas) Limited, January 1992.

A.1.3. Eastern Paktia

A.1.3.1. Part of Province/District

The Eastern Paktia Province has been sub-divided by command areas and rivers systems and then divided according to the Left (LB) and Right Banks (RB) of the river within these command areas. Reference should be made to Figure 2 of the Consultant's fourth report. These are listed below:

RIVER SYSTEM	COMMAND AREA	SYMBOL
Shamal	Shamal Left Bank	SHLB
Shamal	Shamal Right Bank	SHRB
Matun	Matun Left Bank	MALB
Matun/Sulni	Matun Right Bank	MARB/SULB
Shamal/Gorbuz/Groundwater	Gorbuz Left Bank	SHGLB/GOLB/GOGLB
Shamal/Gorbuz/Groundwater	Gorbuz Right Bank	SHGRB/GORB/GOGRB
Shamal	Lund Lakan Left Bank	SHLLLB
Shamal	Lund Lakan Right Bank	SHLLRB
Zamber	Tarakay Left Bank	ZATLB
Zamber	Alisher Left Bank	ZAALB
Zamber/Groundwater	Alisher Right Bank	ZAARB
Zamber	Sewakay Left Bank	ZASELB
Zamber	Sewakay Right Bank	ZASERB
Shamal	Lower Shamal Left Bank	SHLSLB
Shamal	Lower Shamal Right Bank	SHLSRB

A.1.3.2. Irrigation System

The numbers adopted for the canal systems have been derived using the results of the preliminary survey works to ensure that all canals have been correctly identified and are in the right sequence. Within each command area, each canal has been given a reference number. This will start with the number 1 at the upstream end of the command area and proceed downstream with consecutive numbers until the end of the command area. Where branch canals are present, these will be given suffixes (a), (b), etc. The names and numbers of the canals are given on the following tables.

A.1.3.3. Structures

All of the identified structures will be given numbers that relate to the canal on which they are located or are required. They are again numbered from upstream to downstream. The list will be finalized after the survey data have been field checked. Reference should be made to the Kunar Rehabilitation Programme that uses the same system. All planning, design and construction work within the valley will use these reference numbers.

A.1.3.4. Example

For the third wash crossing structure located on the second branch of the sixth canal located within the Shamal command area on the left bank of the Shamal river, the following reference number will

be used:

P / SHLB.6(b).3

- third wash crossing structure
- second branch
- sixth canal
- left bank of the Shamal river
- Shamal command area
- Eastern Paktia

APPENDIX 2

EXAMPLE OF CONTRACT FOR CONSTRUCTION OF STRUCTURES

LETTER OF AGREEMENT FOR CONSTRUCTION WORKS

Date: 30 November 1993

Dear Sir,

Subject: Rehabilitation of Irrigation systems, Kunar Province

Project Symbol: ____________________

Project Title: ____

The Food and Agriculture Organization of the United Nations (hereinafter referred to as "FAO" and (hereinafter referred to as "Recipient Organization) have agreed to cooperate in achieving a particular objective specified in the Project Document/Plan of Operation of the subject project. The modalities of this cooperation as well as the financial terms and conditions are set forth in the enclosed Annex, which constitutes an integral part of this Agreement.

Using resources allocated to the project, FAO thus agrees to grant the Recipient Organization for carrying out/rendering the assigned activities/services a financial compensation in local currency valued at up to but not exceeding US$____________.

The Recipient Organization will be responsible for the timely delivery of the desired results subject to the following general conditions:

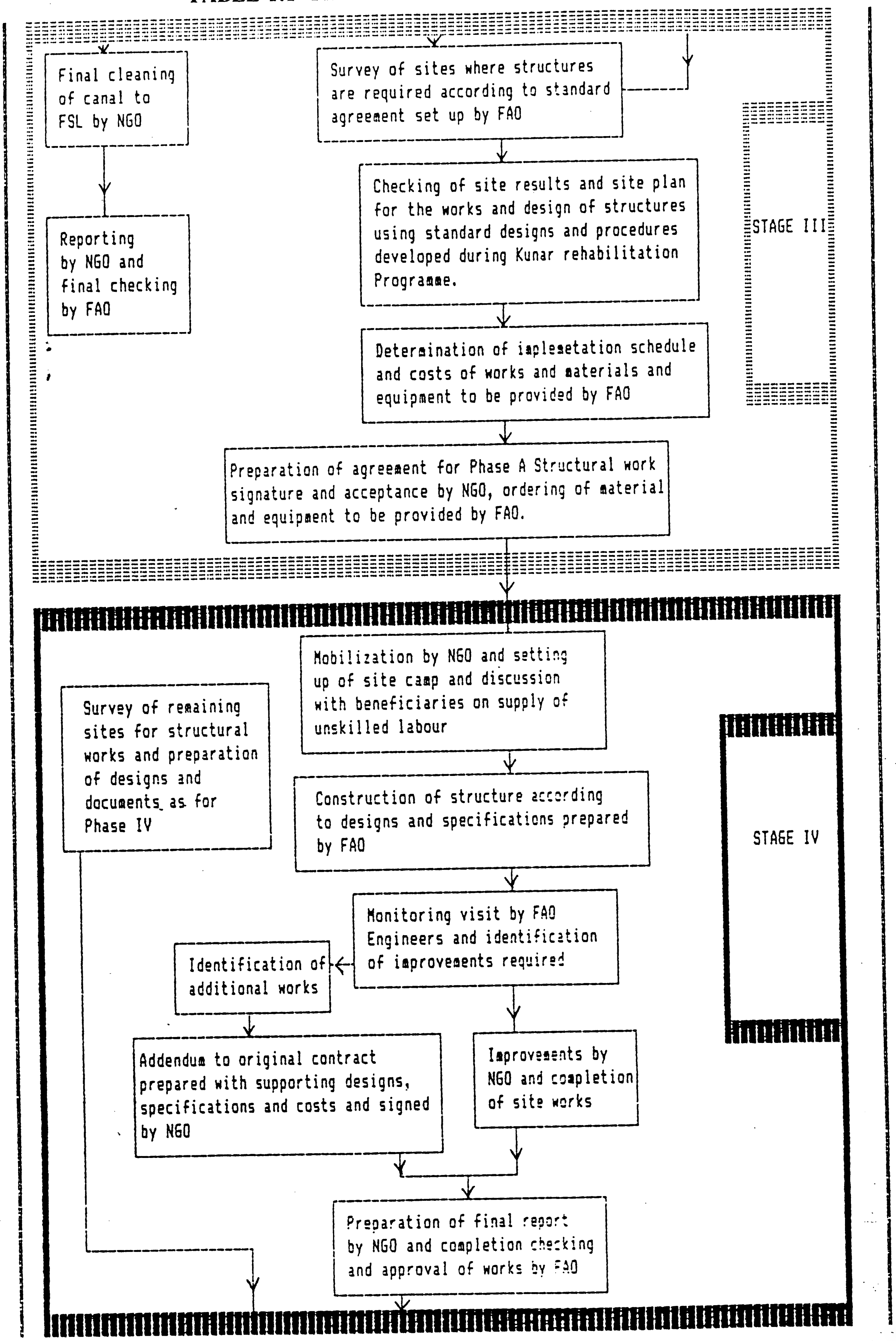
1. The funds provided by FAO are to be used exclusively for the purposes described in the Annex.

2. The personnel of or any other person co-opted by the Recipient Organization will not be:

   (a) permitted to incur any commitments or expenditures on behalf of FAO;
   (b) considered in any way as staff member of FAO and thus not entitled to any privileges, immunities, compensation or insurance coverage normally accord to FAO staff.

   The Recipient Organization is expected to provide for its own insurance requirements in respect of any accident, illness, damage or loss that may occur while the assigned activities/services are being undertaken/rendered.

TABLE 1.1 REHABILITATION PROCESS/continued



3. Any amendment to this Agreement shall be effected only on the basis of written mutual consent by the signatories or their authorized representatives;

4. In the event of the Recipient Organization's non-compliance or partial compliance with the terms of this Agreement, it will refund to FAO any payment received in respect of services/activities that have not been rendered/undertaken by the Recipient Organization to standard considered acceptable by FAO.

If you accept the stipulated terms and conditions please sign this letter Agreement in the space provided below and return the original to me with your banking instructions.

Your sincerely,

A. R Fitzherbert
FAO Programme Coordinator
Afghan Agri. Rehabilitation

enclosure:

A.1	Terms of the Agreement
A.2	General Technical Specifications
A.3	Cost Estimate
A.4	Work Plan
A.5	Detailed Drawing of Proposed Works

We agree to accept the terms and conditions contained in this letter and accompanying document.

Name: ________________________

Title: ________________________

Recipient Organization: ________________________

Location, Country: ________________________

Agreed by: ____________________ ____________________ ____________

(Name and Signature) (Title) (Date)

<u>Banking Instructions</u>

Bank: ________________________________

Location: ________________________________

____

Account Name: ________________________________

Account Number: ________________________________

A.1 TERMS OF AGREEMENT

This Annex sets out the terms and conditions for the agreement between the Food and Agriculture Organization of the United Nations (FAO) and (Recipient Organization) in respec: ...roject UNO/AFG/102/UNA Rehabilitation of Agriculture in the Kunar Province of Afghanistan for the Project (title of agreement).

1. BACKGROUND AND JUSTIFICATION

1.1. Present Situation

The Kunar Province is adjacent to the border of Pakistan in the North-Eastern corner of Afghanistan. Before the war its population was estimated to be between 280,000 - 300,000 largely Pashtoon with some Nuristanis concentrated mainly in the valley. Its area is about 10,300 square kilometres and contains six Woluswali (districts) and about 500 villages.

One of the main resources of the Province is the Kunar River whose catchment covers an area of 26,000 km^2. After leaving its source in the high Pamir mountains, the river flows in a generally southern direction from Pakistan crossing into Afghanistan near Barikot where it is joined by its first major tributary, the Landay river. From there the river passes through the middle Kunar which comprises a narrow valley in which the course of the river is deeply incised. Soon after it is joined by its other major tributary, the Pech river, near Asadabad, the river enters its flood plain passing through what is known as the Lower Kunar. It is in this part of the catchment that the largest area of cultivated land exists covering a gross area of about 10,800 ha. At the southern limit of the Lower Kunar valley the river meets the Kabul river just North of Jalalabad.

Sub-Catchment	Area (km2)	Percentage
1. Upper Kunar[1]	13,955	53.6
2. Landay	3,070	11.8
3. Pech	3,740	14.4
4. Middle Kunar	1,875	7.2
5. Lower Kunar	2,190	8.4
6. Kama	1,205	4.6
Total	26,035	100.0

Although the Province has considerable water resources, the potential for agriculture is very limited. Studies carried out before the war indicated that less than 4 percent of the Kunar river basin within Afghanistan offered a potential for agricultural land use and of this only 2.4 percent was being utilized. Nearly 85 percent of this land use comprised irrigated agriculture, almost all of which is located within the lower Kunar and Pech valleys, being primarily limited to the bottom of the narrow valleys and the river terraces.

The climate in these parts of the Kunar valley is suitable for all year round cropping provided irrigation water is available. In addition to the approximately 10,000 ha of land under rainfed agriculture before the war, some 16,000 ha of land had been brought under irrigation. This was achieved using traditional gravity systems that were served by about 223 medium and minor sized canals whose capacity ranged from a few litres per second up to several cumecs. Water was diverted from the main rivers and streams in the catchment by means of locally constructed stone and brushwood weirs.

The impact of the last eleven years of turmoil within the Kunar Basin on the irrigation infrastructure has been considerable. This has been the result of cumulative neglect to the annual maintenance of the systems rather than from damage due to the fighting. Although many of the systems were still functioning to some degree, their capacity was well below that required to irrigate all the commanded land.

With the taking over of the Province by the Majahadeen in 1988, many farmers started to drift back to their former lands from the refugee camps in Pakistan. In September 1989, FAO initiated a programme to assist them and this began with the introduction of

1 In Pakistan

improved wheat seed (477 MT) and fertilizer (1,146 MT) distributed to farmers through the agency of various NGOs. This was followed by the introduction of fruit tree saplings (31,650) for distribution to farmers plus apple root stocks (1,000) and poplar tree cuttings (9,670) for the establishment of nurseries and propagation.

The success of these initiatives, which acted as an incentive to the people of Kunar to bring abandoned land back into productive use, increased the requirement for irrigation water especially in the wheat growing areas. Although the farmers started to try to clean the canals to get the water to their lands, their reduced numbers, a result of the continued insecurity, and the enormity of the work involved, meant that they would have been unlikely to complete the work in time to save their winter crop.

In December 1989, the FAO fielded an Irrigation Engineer Consultant (Mr. Ian Anderson) to review and assess the situation and make recommendations as to the effective and relevant way in which FAO might start its work on assisting the rehabilitation of irrigation systems in Kunar. Eleven irrigation channels in the lower Kunar valley were identified as being appropriate subjects for FAO intervention. These were selected on the criteria that no other agencies were presently engaged in working on the rehabilitation of these canals, and that there was a critical and immediate requirement for irrigation water in the areas served by these canals both for crops already planted and in order to bring land abandoned during the conflict back into agricultural production.

This programme was divided into two phases, the first of which was aimed at restoring water to all lands as soon as possible. This phase was completed by May 1991. The second phase of the programme follows on directly from the first phase and concentrates upon the construction of appropriate structures within the conveyance systems so that time spent by the farmers on emergency repairs is reduced.

1.2. Target Beneficiaries

The social dislocation and depopulation of the Province due to more than eleven years of war has led to the neglect and consequent disrepair of many of these canals and the abandonment of agricultural land. The major number of these dislocated people live in the Bajaur agency of Pakistan. In order to encourage these farmers to return to their lands and to reduce their dependence upon emergency food rations in the camps in Pakistan, the United Nations has supported a number of programmes aimed at encouraging whole families to return to their former villages and homes.

As part of this, FAO has been supporting the rehabilitation of the agricultural sector. Within the lower Kunar province, this is expected to benefit some 12,250 farm families whose main source of income is derived from agricultural production. If successful, a

total number of 86,000 persons will benefit from the assistance.

1.3. End of Project Situation

By the end of the project, it is anticipated that all of the irrigation systems within the Lower Kunar Valley will be restored to at least the level that they were at before the start of hostilities. At that time almost all of the land that could be commanded by traditional gravity irrigation systems was under irrigated agriculture. In addition to the achievement of this objective, the time that is spent annually upon the repair of canals that cross washes and gulleys will have been considerably reduced by the provision of permanent structures. This is planned to compensate for the lower numbers of farmers presently available within the villages to maintain and repair the systems. In addition, it will permit the farmers to spend more time on the farm management which will be necessary with the introduction of improved seeds and fertilizer use.

2. DEVELOPMENT OBJECTIVE

The overall objective and justification of the project is to restore the agricultural production of Kunar Province at least to its prewar level in a period of two years (September 1989- September 1991). This is seen as a priority that, together with other measures, will help induce the refugees from Kunar Province, now resident in Pakistan and elsewhere, to return to their country and once again support themselves.

It is an impact oriented project aimed at the rehabilitation of the existing productive assets (land, water, power generation) at least to the prewar level and making improvements where possible. The project will be implemented as far as possible with the full participation of the people of Kunar.

3. IMMEDIATE OBJECTIVES

As an indispensable complement and follow-up to the inputs of improved seed, fertilizer and fruit trees for Kunar Province, immediate emergency assistance is required to restore the irrigation canals that support these crops to their full capacity and to ensure that all areas receive sufficient water. In this instance this specifically covers the crossings and other structures of the ________________________ canal in ________________ district of Kunar Province.

Prior to the war seasonal maintenance of irrigation canals was carried out by the farmers themselves. The conflict over the past ten years and the flight of the population from the Province has led to a breakdown of essential repair and maintenance work and the consequent collapse of irrigation systems due mainly to neglect. Phase I of the FAO Rehabilitation programme included the cleaning of these canals to restore them to their

original capacity. Although this has encouraged farmers to return and bring much of the land back under cultivation, the total numbers of farm families is less than before.

The immediate object of this agreement is to construct canal structures at key locations where farmers spend much time annually repairing damage caused by runoff from the surrounding hills.

3.1. Activities

3.1.1. The provision of suitably experienced technical staff for the supervision of construction of the planned works based on the designs provided by FAO.

3.1.2. The provision of skilled and unskilled labour as required for the construction of the planned works based on the designs provided by FAO.

3.1.3. The collection of all construction materials on site including locally available stone, sand and gravel as well as material provided by FAO at its store in Salarbagh.

3.1.4. The construction of the works according to the designs, specifications and work plans prepared by FAO.

3.2. Outputs

A completed irrigation structure capable of meeting the design requirements for the conveyance of water between two specified locations.

4. IMPLEMENTATION ARRANGEMENTS

4.1. Strategy

The NGO will engage suitably experienced professional staff who will plan and supervise the construction of the works. They will maintain a permanent site engineer for the duration of the works until the site has been passed as completed by the FAO Irrigation Engineer. He will be guided and supervised by experienced engineers from the headquarters of the NGO in Peshawar who will visit the site frequently.

Regular monthly reports will be provided to the FAO Engineer on the progress of the works. Any problems or delays that may affect the ultimate objective of the project will be brought immediately to the attention of the Engineer.

The NGO will employ sufficient skilled and unskilled staff and mobilize all the necessary resources to ensure that the works are completed to the highest standard and within the planned time scale.

4.2. Selection of Implementing Agency

______________________________ is a non-profit making non- political technical aid agency that is already actively involved in rehabilitation work in Kunar Province. Its relations with the local authorities (Shuras, Commanders and People) are known to be excellent. ______________ are already actively involved in rehabilitation work in Kunar aimed at encouraging the return of the refugee Population from Pakistan, and elsewhere; and are considered to have the capacity to undertake the work of ______________________ required if supported by FAO financially and technically, through integration in FAO Project UNO/AFG/102/UNA - Rehabilitation of Kunar.

5. RISKS AND CONSTRAINTS

There is a risk that the works will be delayed if previous security problems recur in the valley. This will be reduced by ensuring that all material are collected on site at the start of the construction works.

Previous delays were experienced by NGOs in obtaining and transporting to site materials and equipment not available from within Afghanistan. This constraint will be reduced by the bulk purchase of such materials in Pakistan by FAO and the transporting of the same to the FAO store in Kunar Province.

The NGOs have been advised that they must employ suitably experienced engineers on site and that they must be properly supervised from their head office in Peshawar. Failure to abide by this may result in a lower standard of work and delays in completion

6. INPUTS

FAO will provide all materials listed in Appendix A.4, Cost Estimate, and not available within the Kunar Province at the FAO store in Salarbagh in Kunar. This includes cement, reinforcement bars, and gabions. FAO will also reimburse the NGO for the sum of all the other construction costs incurred in the execution of the work as set out in Appendix 4 and not exceeding the sum of Pakistan Rupees __________.

To assist the NGO in the construction work, FAO will provide the following small construction equipment:

-	Concrete Vibrator	1
-	Concrete Mixer	1
-	Water Trailer	1
-	Hand Rock Drills	1
-	Big Hammer	4
-	Wheel Barrow	4
-	Tool Kit	1

These will be loaned to the NGOs for duration of the construction works. The equipment will be kept in the FAO store in Lower Kunar when not in use and the NGOs will be responsible for transporting the equipment from the store to the work site. They will also be responsible for running and maintaining the equipment and for returning it in good order back to the FAO store on completion of the contract.

7. BUDGET AND PAYMENT SCHEDULE

The total cost of the construction works is estimated at Pakistan Rupees _________. Of this total, Pakistan Rupees _________ will be paid to the NGO in the following installments:

1st Installment -	25 percent of the Contract sum due to the NGO on signature of the agreement.
2nd Installment-	30 percent of the Contract sum due to the NGO on satisfactory completion of 50 percent of the work as estimated by the FAO Engineer.
3rd Installment -	30 percent of the Contract sum due to the NGO on satisfactory completion of 100 percent of the work as estimated by the FAO Engineer.
4th Installment -	15 percent of the Contract sum due to the NGO on approval of the work by the FAO Engineer and after the safe return of the FAO equipment to the FAO store in Kunar in good working order and the presentation of satisfactory accounts according to FAO procedures.

A.2 GENERAL TECHNICAL SPECIFICATIONS

TABLE 1.1 REHABILITATION PROCESS/continued

Implementation of Phase B of the structural programme following the same process and procedures as for Phase A (Stage IV)	STAGE V

A.3 COST ESTIMATE

A.4 WORK PLAN

A.5 DETAILED DRAWING OF PROPOSED WORKS

APPENDIX 3

GENERAL AND TECHNICAL SPECIFICATIONS

GENERAL AND TECHNICAL SPECIFICATIONS

A.3.1. PREPARATION OF SITE

A.3.1.1. Setting-out

The Contractor shall be entirely responsible for accurate setting-out of the works including staking of canal centerlines and reference pegs based on the information supplied from the Drawings and the instruction given by the Engineer. The costs to conform to the requirements of this Clause shall be covered by the supervision costs as given in the Bill of Quantities.

A.3.1.2. Temporary Works and Care during Construction

The Contractor shall construct and maintain all necessary channels, diversions and other temporary works necessary to ensure that irrigation water supplies are not interrupted during rehabilitation construction works; shall furnish all materials required therefore; and shall furnish, install, maintain, and operate all necessary pumping and other equipment (if necessary) for maintaining water supplies around the rehabilitation works.

After having served their purpose, all temporary works at the construction site shall be removed in a manner approved by the Engineer, and such areas after those are removed shall be levelled and graded to the extent required to prevent obstruction in any degree whatever and maintaining the designed function of the structure.

The Contractor shall be responsible for and shall repair at his expense any damage to the foundations, structures, or any other part of the works caused by floods, water or failure of any part of the temporary diversion or protective works.

During placing and setting concrete in the cutoff trench or any part of the structures, the water table shall be maintained below the bottom of the newly placed concrete.

A.3.1.3. Clearing and Grubbing

During the Contractor's operations, the removal of certain trees and shrubs may be required, in which case, the Contractor shall remove such trees and shrubs after seeking prior approval from the Engineer. All trees and shrubs to remain in place shall be protected from damage. Where clearing is required, all combustible materials from clearing operations shall be burned or removed from the site for otherwise disposed of as directed by the Engineer.

All materials to be burned shall be piled neatly and when in a suitable condition shall be burned completely. Piling for burning shall be done in such a manner and in such locations as to cause the

least fire risk. All burning shall be so thorough that the cleared materials will be reduced to ashes. The Contractor shall at all times take special precautions to prevent fire from spreading.

A.3.2. EXCAVATION AND BACKFILLING

A.3.2.1. Excavation for intakes, wash crossings, flumes and bank protection works

Excavation for intakes, wash crossings, flumes and bank protection works shall generally be executed in such a manner as to ensure that the side slopes, as shown on the drawings, are not in anyway endangered by undercutting.

As far as practicable, all suitable materials from the excavations shall be used in embankment and backfill for structures. The Contractor shall dispose of unfit or excess soil of the excavated materials in a place that is acceptable to the local community and so that they do not interfere with the proper functioning of the works.

The Contractor shall execute and complete the construction of the structures in accordance with the drawings and in conformity with the relevant clauses provided hereinafter, unless otherwise directed by engineer.

All excavation shall be carried out to the lines and levels shown on the drawings or to such lines and levels as the engineer may direct. The Contractor shall trim all permanent excavation to the lines and levels shown on the drawings.

All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavation in the soundest possible condition. Any damage to the work due to the Contractor's operations, including shattering to the material beyond the required excavation lines, shall be repaired at the expense of and by the Contractor. Any and all excess excavation or over excavation performed by the Contractor for any purpose or reason, except as may be ordered in writing by the Engineer,and whether or not due to fault of the Contractor, shall be at the expense of the Contractor. Where required to complete the work, all such excess excavation and over excavation shall be filled with materials furnished and placed at the expense of and by the Contractor.

The bottom and side slopes of excavation against which concrete is to be placed shall be finished accurately to the dimensions shown on the drawing or prescribed by the Engineer and the surface so prepared shall be moistened with water and tamped or rolled with suitable tools or equipment for the purpose of securing a firm foundation. If at any point the natural foundation material is disturbed during the excavation process or otherwise, it shall be compacted in place, or it shall be removed and replaced with suitable earth materials or concrete at the expense of the Contractor.

A.3.2.2. Embankments

This shall include the construction of all embankments for canals and the filling on other parts of the works with suitable materials obtained from canal excavation or extracted from borrow areas. All embankments shall be constructed to the lines and levels shown on the drawings or as directed by the Engineer. The materials for embankment shall not contain any stump, brush, weed root, clod and any matter that may decay.

During placing and spreading, the materials shall be thoroughly compacted by hand tampers. The distribution of the materials shall be such that the tamped materials will be homogeneous and free from lenses, pockets, streaks or other discontinuities.

A.3.2.3. Backfilling

Backfilling shall be placed in 0.2 meter layers and thoroughly compacted. Top soil, vegetation or other organic materials shall be excluded from backfilling material. Such materials shall be placed in such a manner as will ensure that they can satisfactorily be compacted without damage to the structures.

A.3.3. CONCRETE WORKS

Concrete shall consist of cement, graded aggregates, water and thoroughly mixed and compacted to provide strengths as specified herein. The concrete is classified on the basis of its compressive strength at twenty eight (28) days as well as on the maximum size of the aggregates as shown below:

Type of concrete mixes 1/	Specified compressive strength at a 28 day age (kg/cm2)	Maximum size of aggregtes (mm)	Maximum water/cement ratio (%)	Approx. cement content (kg/m3)
A (K-225)	225	40 (20)	50	330 (350)
B (K-175)	175	40	50	300
C (K-125)	125	80	55	250
D (K-100)	100	20	60	200

Type	Description
Type A :	Reinforced concrete for superstructure of bridge, flume, precast concrete slab, etc.
Type B :	Reinforced concrete for various types of concrete structures and concrete lining.
Type C :	Plain concrete for mass concrete.
Type D :	Plain concrete for foundation and filling purpose.

A.3.3.1 Storage of Cement at the Works

Immediately upon receipt at site of work, the cement shall be stored in a dry, weathertight, properly ventilated structure, with adequate prevention of absorption of moisture and in stacks of not greater tha six bags.

A.3.3.2 Concrete Aggregates

All concrete aggregates shall be furnished by the Contractor from any sources approved by the Engineer. They shall be free from earth, clay, chalk, lime, peat, loam, soft clayey shale or decomposed stone, vegetable and organic matter and other impurities. The stone shall be hard and dense. The coarse aggregates shall consist of natural gravel or crushed rock or a mixture of natural gravel and crushed rock and its particles shall be generally spherical or cubical in shape.

The maximum nominal size of the coarse aggregate shall be eighty (80) millimetres in massive concrete structures, forty (40) millimetres in structural concrete and twenty (20) millimetres in other thin structures.

A.3.3.3. Mixing Concrete by Machine

The concrete ingredients shall be mixed in the mixer provided for not less than 1.5 minutes after all ingredients, except full amount of water, are in the mixer. All mixing water shall be introduced before one-fourth of the mixing time has elapsed. The mixers shall not be loaded beyond their rated capacity, nor be operated at a speed in excess of that recommended by the manufacturer. They shall produce a concrete of uniform consistency and appearance. All mixing equipment shall be clean before commencing mixing and shall be kept free from set concrete.

A.3.3.4. Mixing Concrete by Hand

Where concrete is mixed by hand, this shall be done as near as practicable to the site where it is to be deposited. Clean mixing bankers of platforms of sufficient areas for the proper execution of the work shall be provided. These platforms if constructed of timber shall consist of planks closely jointed so as to avoid the loss of any grout or liquid from the wet concrete. The whole of the aggregates and cement shall be turned over on the banker in a dry state at least three (3) times. The water shall then be added gradually through a rose head, after which the materials shall again be entirely turned over in a wet state at least three (3) times before leaving the banker.

A.3.3.5. Foundation Preparation for Concrete

Before placing concrete on foundations, the Contractor shall remove from all such surface oil, objectionable coatings, loose or unsound fragments of earth mud, debris and standing water, to the satisfaction of the Engineer and he shall keep such surfaces clean and free from standing water during concreting operations.

Where new concrete is to be deposited on or against rock, the surface of the rock shall be toothed to form an adequate bond, roughened if necessary, cleaned, shall then be mortared. The mortar shall have the same sand/cement ratio as used in the concrete. No mortar shall be required on foundations where a concrete blinding layer or other foundation protection is specified.

A.3.3.6. Depositing Concrete

The arrangements for placing concrete are to be such that in all cases the material may be conveniently handled and placed in the required position without rehandling or segregation. In placing concrete through reinforcement, care shall be taken that no segregation of the coarse aggregate occurs. On the bottom of beams or slabs, where the congestion of steel near the forms makes placing difficult, a layer of mortar of a composition compatible with the required concrete strength as directed shall be first deposited to cover the surface to a depth of approximately 3 cm.

Concrete shall not be placed in or in contact with standing or running water unless so specified or approved. Water accumulating during placing shall be removed. Concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a construction joint is formed as hereafter specified. When stoppage of concreting operations occurs for any reason, construction joints shall be placed. Before concreting operations are resumed, the surface of the concrete shall be cut or chipped to remove all laitance and to expose the aggregate. The surface of the concrete shall be thoroughly saturated and coated

with a proportion by weight of 1:2 cement mortar one (1) centimeter thick before the placing of the concrete is resumed. The cost of all roughening of surface shall be deemed to be included in the unit prices for concrete in the Bill of Quantities.

Concrete in reinforced concrete work shall be deposited in small quantities in a plastic state with a water cement ratio such as to give the specified strength. The depositing of concrete in individual members shall be continued without stoppage up to an approved pre-arranged construction joint or until the member is completed and shall be finished off in such a manner that the junction of members shall be monolithic unless otherwise specified.

A.3.3.7. Temperature of Concrete

The temperature of concrete, when it is being placed, shall be not more than 32° C. If concrete is placed when the weather is such that the temperature of the concrete will exceed 32°C, the Contractor shall employ effective means, such as placing at night, as necessary to maintain the temperature of the concrete, as it is placed, below 32° C. The Contractor shall not be entitled to demand additional compensation on account of these requirements.

A.3.3.8. Vibration of Concrete

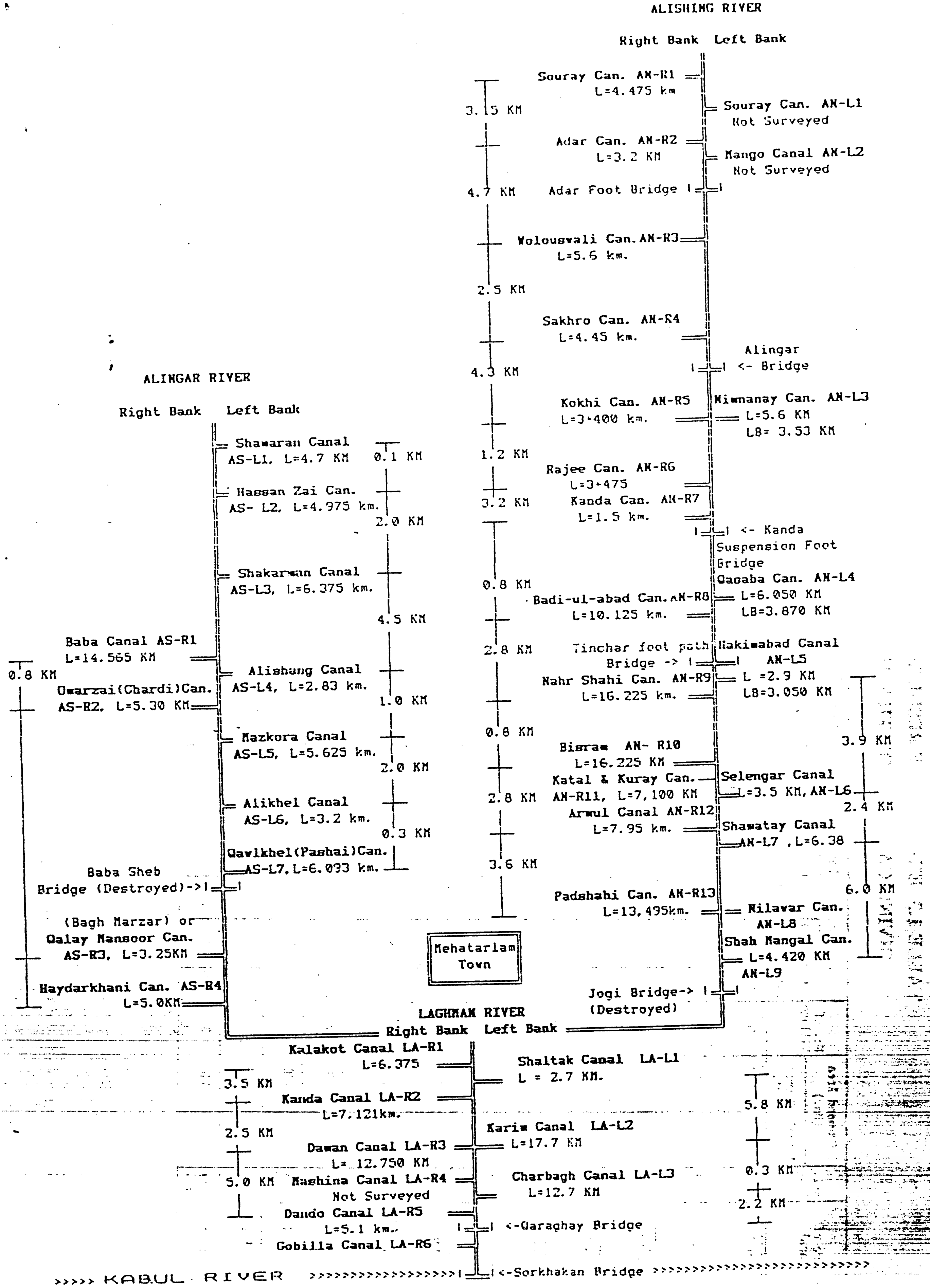
Except where otherwise permitted by the Engineer, concrete shall during placing be compacted by internal vibrators provided by FAO. The duration of vibration shall be limited to that required to produce satisfactory consolidation, without causing segregation. Vibration shall, on no account, be continued after water or excess grout (if any) appears on the surface.

In consolidating each layer of concrete, vibrators shall be employed in a systematic manner, and concrete in one layer shall be thoroughly consolidated in such a manner as to be tightly bonded to all surfaces of the forms and embedded materials, before placing the next. The vibrating head shall be withdrawn slowly to ensure complete closure of the hole in the concrete, which it has formed. Care shall be taken to avoid contact with the reinforcement and surfaces of the forms and to avoid excessive local vibration. Freshly placed concrete shall not be vibrated in a manner likely to cause damage to concrete in other parts of the work, which has already set.

A.3.3.9. Curing and Protection

The Contractor shall take adequate measures to ensure that the concrete shall be kept damp continuously for a minimum period of three (3) days after casting or for such other time as the Engineer may direct. After removal of this covering, the concrete shall then be sprayed with water for minimum period of a further seven (7) days.

TABLE 1.2 TYPICAL FLOW DIAGRAM FOR CANAL SYSTEMS



Note: Example taken from Laghman Command Area, Laghman Province (1993)

FAO PROGRAMME FOR THE REHABILITATION OF AFGHANISTAN

REHABILITATION OF INFORMAL IRRIGATION SYSTEMS IN AFGHANISTAN

DESIGN MANUAL

Prepared by
IAN MCALLISTER ANDERSON
Irrigation Consultant

NOVEMBER 1993

All concrete liable to be affected by running water or wave action shall be adequately protected from damage during the setting period and all temporary protection works shall be to the satisfaction of the Engineer.

A.3.3.10. Form Work

Form shall be used, wherever necessary, to confine the concrete and shape it to the required lines. The formwork is to be of timber, steel or other suitable and approved materials which shall be sufficiently strong, and shall conform to the shapes, lines and dimensions of structures shown on the drawings. Forms shall be braced and strutted to withstand the pressure resulting from placing and vibrating the concrete, construction loads, wind and other forces without appreciable deformation.

Before placing any concrete, all bolts and the like (if required and which are to be built in) shall be fixed in their correct positions, and cores and other devices for forming holes, openings, etc., shall be fixed to the forms. No holes shall be cut in any concrete unless approved by the Engineer.

The Contractor shall take full responsibility that the time has elapsed for the concrete to attain sufficient strength before forms are removed. Nevertheless, the forms shall not be struck until at least three (3) days have elapsed. Connection shall be so formed as to permit the easy removal of the forms without hammering, etc. and without the necessity of levering against the surface of the concrete.

A.3.3.11. Placing of Reinforcement Steel

All reinforcement bars shall, immediately prior to placing, be free from loose mill scale, loose rust, oil, grease, dirt or other foreign matter. Reinforcement is to be placed and secured in the exact position as indicated on the drawings and kept in the correct position in the forms without displacement during the process of vibrating, tamping and ramming the concrete in place. All free ends of the plain round bars shall have hook as shown on the drawings or as directed by the Engineer. Bars shall be bound together with best mild steel wire which shall be twisted tight with proper pliers. The free ends of the binding wire shall be bent inwards.

A.3.3.12. Cover to Reinforcement Steel

The minimum concrete cover to reinforcement steel measured from the outside of the bar shall be in accordance with the table below, unless shown on the drawings or directed by the Engineer.

Kind of Structure	Inside part (cms)	Outside part (cms)	Invisible part (cms)
1. Slab	1.0	1.5	2.0
2. Wall	1.5	2.0	2.5
3. Beam	2.0	2.5	3.0
4. Column	2.5	3.0	3.5
5. Structure directly facing soils or expected to weather or scour	5.0	-	-

A.3.3.13. Precast Concrete Units

The Contractor may manufacture the precast concrete units at the site with the approval of the Engineer in accordance with the Specifications. All materials to be furnished and used for precast concrete units by the Contractor shall conform to the requirements of this section or shall be approved by the Engineer. Forms or molds of concrete units shall conform to shapes, lines and dimensions as shown on the drawings or may be directed by the Engineer, and the Contractor shall submit details of the form or mold proposed for the approval of the Engineer.

Precast concrete units to be manufactured at the site shall be of concrete with adequate strength for bearing loads as directed by the Engineer. The concrete units shall be cast in horizontal position, unless otherwise directed by the Engineer. The concrete shall be placed continuously in each of these units and compacted by vibrating in a manner acceptable to the Engineer. Special care shall be exercised in tamping and vibrating the concrete so as not to displace the reinforcement.

The concrete units shall remain in their molds for three (3) days before being stripped, during which time the exposed face shall be covered with sacking or matting and kept constantly wet; in addition, the sides of the forms or molds shall be shielded from the direct rays of the sun. After removal of forms or from the molds, the units shall be kept moist continuously for a minimum period of eleven (11) days. After stripping, such units shall be stacked for a period of not less than thirty (30) days, unless otherwise directed by the Engineer, so as to leave a free air space between each of these precast units. Each of such precast units shall be clearly marked with the date of casting, if prescribed by the Engineer.

A.3.4. STONE WORKS

A.3.4.1. Stone for Masonry

Stone used in masonry shall be regular field, river or quarry stone of approved quality, free from seams and other defect. The stone shall have a specific gravity of not less than 2.5. All masonry stone shall be kept slightly moist at the time of use. Stone used in the work or any part of the works shall be approximately of uniform size to ensure no large voids between stones. The maximum size of the masonry stone shall be two-thirds of the wall thickness. Round stone will be permitted only in limited amount in combination with angular stone and shall not be used in walls having a thickness less than forty (40) centimeters.

A.3.4.2. Cement Mortar for Jointing

The stone masonry will be divided into two (2) types, Type A and Type B, according to cement mortar used for jointing. The cement-sand ratio by volume is given in the following table:

Type of stone masonry	Ratio of cement-sand
Type A	One part of portland cement to three sand (1 : 3)
Type B	One part of portland cement to four sand (1 : 4)

Type A stone masonry shall be used for protection work against abrasion and attack by boulder and gravel. Type B stone masonry shall be used for all stone masonry structure such as flumes, walls, piers, transition of canal structures, etc.

A.3.4.3 Placement

Before placing stone, the stone shall be sufficiently moist. The masonry stone shall be so placed by hand that each stone is completely surrounded by mortar. Cement mortars specified herein shall be used for jointing according to the type of stone masonry. The stone shall be fitted into place in such a manner that the mortar is in complete contact with the mortar in all joints. The stone shall be struck and consolidated by means of a steel hammer and those thereafter broken shall be removed cleaned and re-used with new mortar. The joints shall be liberally provided with mortar and shall be tightened by driving and wedging stone chips into joints. Care shall be taken that each stone is completely enveloped in mortar.

A.3.4.4. Surfacing and Pointing

Joints on the face of all stone masonry exposed to view shall be neatly finished. The mortar in the joints of the stone masonry shall first be removed to a depth of three (3) centimeters. The joint shall then be cleaned thoroughly with a wire brush of all loose materials and filled with cement mortar with a mix proportion of one portland cement and two sand by volume (1:2). The surface of the face stone shall be cleaned of all mortar upon completion of the finishing operation.

A.3.4.5. Plastering

The top of stone masonry structures such as walls, piers, abutment, etc., shall be finished neatly by plastering cement mortar with mix proportion of one portland cement and three sand by volume (1:3). Where such plastering is to be used to fill in joints of either stone masonry or dry stone pitching, cement mortar with mix proportion of one Portland cement and two sand by volume (1:2) shall be used. Before plastering, mortar in the joints of the stone masonry shall first be removed to a depth of three (3) centimetres. The joint and top portion shall then be cleaned thoroughly with a wire brush of all loose materials and plastered with such a cement mortar.

A.3.4.6. Contraction Joint

In masonry lining contraction joints shall be provided at intervals of twenty (20) metres or less except as otherwise designated on the drawings or as directed by the Engineer. The contraction joint shall be a straight line perpendicular to the flow direction and, where it is necessary on such horizontal surfaces as floors, shall be parallel to the flow direction.

A.3.4.7. Riprap Protection

The Contractor shall furnish and place riprap protection to the prescribed lines, elevation and thickness as shown on the drawings or as directed by the Engineer. For structures with a flow width of more than one and a half (1.5) metres, this riprap will be provided for a minimum distance of two (2) metres upstream and three (3) metres downstream from the structure. For flow widths of less than one and a half (1.5) metres, the rip rap will be placed as directed by the Engineer.

The rock shall be hard, dense and durable. Either quarried rocks or boulders may be used for riprap. The sources of the riprap materials shall be subject to the Engineer's approval. Unless otherwise specified on the drawings, the size of the riprap rock shall not be less than twenty (20) centimetres and not more than thirty (30) centimetres.

Before placing riprap rocks, the bedding which consists of well-graded sand shall be provided with the required thickness shown on the drawings or as directed by the Engineer. Such a sand bedding shall be compacted thoroughly by mechanical tampers. The rocks in the riprap shall then be dumped and graded off on such a sand bedding.

A.3.5 GABION WORKS

A.3.5.1 Wire for Gabions

The wire used in the manufacture of gabions, mattresses and lacing wire is to be heavily coated mild steel. The wire used shall have a tensile strength, before manufacture, of 38-50 Kg/mm^2. Elongation test must be carried out prior to manufacture on a sample of not less than 0.30m in length and the elongation shall not be less than 12%. Zinc coating and tolerances should be as shown in the table below.

Diametre of Mesh Wire (mm)	Wire Tolerance (+/- mm)	Quantity of Zinc (gr/m^2)
2.00	0.06	240
2.20	0.06	240
2.40	0.06	260
2.70	0.08	260
3.00	0.08	275
3.40	0.10	275
3.90	0.10	290

Quality control of the locally produced Pakistani Gabions for work in Afghanistan is difficult and thus, unless specified otherwise, a wire thickness of 3.00 mm must be used for all river training works. This thickness and the quality of zinc coating must be checked on receipt of the gabions from manufacture as inconsistencies in deliveries have been noted.

Lacing wire used for the closing of gabions and mattresses is supplied at the rate of 5% of the gabion weight. The thickness of wire used depends upon the diametre of the mesh wire and must conform with those given in the table below.

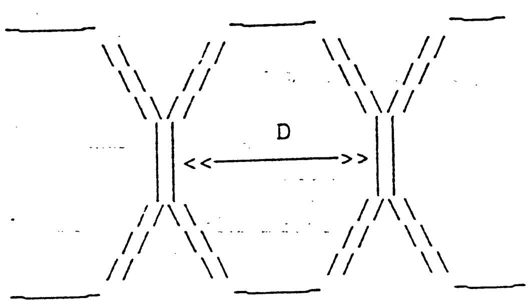
Diametre of Wire (mm)	
Mesh Wire	Lacing Wire
2.00	2.00
2.20	2.00
2.40	2.00
2.70	2.20
3.00	2.40

In order to reinforce the structure, all edges are to be selvedged with wire having a greater diametre than the gabion or mattress wire. This depends upon the diametre of the mesh wire and must conform with those given in the table below.

Diametre of Wire (mm)	
Mesh Wire	Selvedge Wire
2.00	2.40
2.20	2.70
2.40	3.00
2.70	3.40
3.00	3.90

A.3.5.2 <u>Stone for Gabions</u>

Stone used in gabion works shall be regular field, river or quarry stone of approved quality, free from seams and other defect. The stone shall have a specific gravity of not less than 2.5 and be in the size range of 0.15 to 0.35m. Small stones should be avoided. Stone used in the work or any part of the works shall be approximately of uniform size to ensure no large voids between stones. The stones used should have a minimum size of not less than "D" and not greater than 3.5 times "D" where "D" is the specified mesh widths as given below. Larger stones can be used provided that their total volume does not exceed 5% of the cell volume.



MESH SIZE

Where "D" is the distance between the axes of the twists.

Before placing riprap rocks, the bedding which consists of well-graded sand shall be provided with the required thickness shown on the drawings or as directed by the Engineer. Such a sand bedding shall be compacted thoroughly by mechanical tampers. The rocks in the riprap shall then be dumped and graded off on such a sand bedding.

A.3.5 GABION WORKS

A.3.5.1 Wire for Gabions

The wire used in the manufacture of gabions, mattresses and lacing wire is to be heavily coated mild steel. The wire used shall have a tensile strength, before manufacture, of 38-50 Kg/mm^2. Elongation test must be carried out prior to manufacture on a sample of not less than 0.30m in length and the elongation shall not be less than 12%. Zinc coating and tolerances should be as shown in the table below.

Diametre of Mesh Wire (mm)	Wire Tolerance (+/- mm)	Quantity of Zinc (gr/m^2)
2.00	0.06	240
2.20	0.06	240
2.40	0.06	260
2.70	0.08	260
3.00	0.08	275
3.40	0.10	275
3.90	0.10	290

Quality control of the locally produced Pakistani Gabions for work in Afghanistan is difficult and thus, unless specified otherwise, a wire thickness of 3.00 mm must be used for all river training works. This thickness and the quality of zinc coating must be checked on receipt of the gabions from manufacture as inconsistencies in deliveries have been noted.

Lacing wire used for the closing of gabions and mattresses is supplied at the rate of 5% of the gabion weight. The thickness of wire used depends upon the diametre of the mesh wire and must conform with those given in the table below.

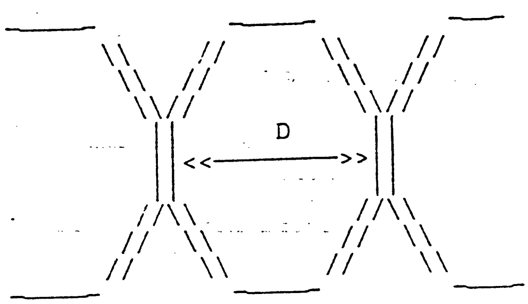
Diametre of Wire (mm)	
Mesh Wire	Lacing Wire
2.00	2.00
2.20	2.00
2.40	2.00
2.70	2.20
3.00	2.40

In order to reinforce the structure, all edges are to be selvedged with wire having a greater diametre than the gabion or mattress wire. This depends upon the diametre of the mesh wire and must conform with those given in the table below.

Diametre of Wire (mm)	
Mesh Wire	Selvedge Wire
2.00	2.40
2.20	2.70
2.40	3.00
2.70	3.40
3.00	3.90

A.3.5.2 Stone for Gabions

Stone used in gabion works shall be regular field, river or quarry stone of approved quality, free from seams and other defect. The stone shall have a specific gravity of not less than 2.5 and be in the size range of 0.15 to 0.35m. Small stones should be avoided. Stone used in the work or any part of the works shall be approximately of uniform size to ensure no large voids between stones. The stones used should have a minimum size of not less than "D" and not greater than 3.5 times "D" where "D" is the specified mesh widths as given below. Larger stones can be used provided that their total volume does not exceed 5% of the cell volume.



MESH SIZE

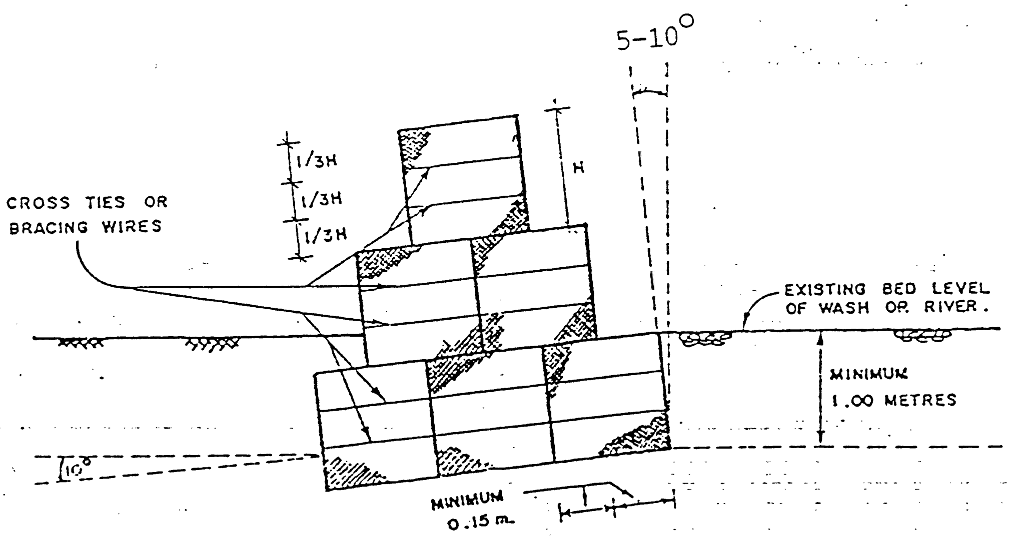
Where "D" is the distance between the axes of the twists.

A.3.5.3 Filling and Placement

Before placement, the foundation onto which the gabions will be placed should be levelled to the correct grade and prepared so that the basket sits flat without distortion. Particular care must be paid to ensure that the minimum foundation depth requirements as specified on the drawings is followed. For river training works, the gabions must extend for a minimum of 1.00 metres below the lowest river bed depth at that location.

Excavation for gabions must be done by hand or backhoe as near as possible to the dimensions of the gabion box. Sides to the excavation must be as near to the vertical as possible to ensure minimum disturbance to the remaining material. Where there is danger of slippage, temporary timber shoring must be provided. If over excavation is carried out, the backfill material must be placed in compacted layers of 0.15m maximum thickness.

Because there may be small horizontal movements associated with the settlement or consolidation, walls must not be constructed with a vertical front face as it subsequently may tilt forwards slightly. All gabion walls must be constructed with the front face at a slight angle to the vertical (10:1 - Vertical:Horizontal). This should be achieved by sloping the foundation accordingly as shown in the diagram below:



Before filling, adjacent baskets should be secured together using steel lacing wire provided for the purpose and conforming with the specifications above (paragraph 1.2). The sides must be secured in straight lines with no gaps left between the sides of adjacent baskets. Where more than one layer of baskets is laid, they must be placed as shown on the Drawings or as directed by the Engineer with a minimum step of 0.15m between the faces of the lower and upper gabion boxes.

All gabions must be connected to each other along corners with the same lacing operation. For a correct lacing operation, the wire should be passed through each mesh, making a double twist every other mesh.

Careful attention must be given to the filling operation to ensure that the stones are placed evenly in the baskets and that there are the minimum of voids between the stones. Smaller stones can be used to fill the central voids of the boxes, but all external stones must be at least 1.5D where D is the diametre of the mesh (see above).

The stones selected for the top layer of gabion baskets must have a flat surface to ensure that the wire does not rest on sharp corners. They must have a minimum dimension of 1.5D in all directions and be placed to ensure a minimum number of voids.

Bracing wires must be fixed at depths of 1/3H and 2/3H where "H" is the height of the gabion box. The horizontal distrance between the bracing wires should also be 1/3H thus for a gabion basket of 1m x 1m x 1m dimension, four bracing wires are provided and for a gabion basket of 2m x 1m x 1m dimension, eight bracing wires are provided. For the gabion boxes used on the project, the bracing wires should be placed at the following depths and spacing:

Gabion Dimensions			Depth of bracing wire from bottom of gabion (metres)		Horizontal Distance between bracing (metres)			
Length (m)	Width (m)	Depth (m)	1st Brace	2nd Brace				
2.00	1.00	1.00	0.35	0.70	0.40	0.80	1.20	1.60
1.00	1.00	1.00	0.35	0.70	0.35	0.70	-	-
2.00	1.00	0.50	0.25	-	0.40	0.80	1.20	1.60
1.00	1.00	0.50	0.25	-	0.35	0.70	-	-

TABLE 1.3 EXAMPLE OF RESULTS OF INVENTORY SURVEY GIVING CANAL PRIORITIES AND NEEDS

S. No	Name of Canal	Ref. No.	Command Area (Ha.)		No. of Village	Average Canal Details					Nature of Work Already Undertaken					Work Proposed by Beneficiaries		Priority for Rehab.	Notes
			Actual	Farmer Est.		Length (m)		Average Width (m)			Loca-tion	Type	Date	Agen-cy	Remarks	Structure/ Activity	Station		
						Main	Branch	Start	Middle	End									
1	Kakrak	SURK R01	160	500	5	3400	1000	1.8	1. 2	0.1	0+00 0+575 1+900	Int WC WC	1989 1992 1992	UNHCR RDA RDA	The intake is functional. The Structure is OK. The structure is OK.	RW RW	1+400 -1+450 2+550 -2+590	2	Two Retaining Walls are suggested.
2	Naw Ju	SURK R02	45	240	2	1400	200	1.0	0. 8	0.4	-	-	-	-	-	Cl Int WC	Main 0+000 1+025 -1+065	1	Cleaning, Intake and a Wash Crossing structures are required. No water flow.
3	Barina	SURK R03	90	150	1	1800	200	1.0	-	-	-	-	-	-	-	Cl Int RW	Main 0=000 0+700 -0+850	1	Cleaning of the canal, Intake, and a Retaining Wall are required. No water flow.
4	Pala Bagh	SURK R04	830	1200	15	7200	3000	2.5	2. 0	0.8	0+00	Int WC	1992	ADA	Reconstruction of the WC is suggested.	Int RW RW	0+000 1+500 -1+525 1+925 -1+975	2	An Intake and 2 Retaining walls are required.
5	Kushkak	SURK R05	255	600	4	3800	1500	1.5	1. 0	0.6	1+175				A Culvert is Under Construction by NCA at ST 1+150- 1+170	Int	0+000	3	Intake Structure is required.
6	Saidan Arabi	SURK R06	280	360	6	4500	1000	1.5	1. 0	0.5	1+725	Flum	1975	Govt.	The Structure Functions.	Cl Int Cul	0+000 1+280 -1+385	2	Cleaning, Construction of Intake an a Culvert are requird.
7	Sultan Pur Bala	SURK R07	475	700	5	6000	2000	1.5	-	-	-	-	-	-	-	LMC Int Cul	0+000 0+168- 0+385	4	Land Mine Cleaning is the first priority.
8	Sultan Pur Payan	SURK R08	730	700	4	5000	3000	1.5	-	-	-	-	-	-	-	LMC Int	0+000	4	Land Mine Cleaning is the first priority.
9	Saidan Foladi	SURK R09	865	360	4	2000	1000	1.5			0+00	Int	1993		-	LMC		4	Land Mine Cleaning is required
10	Masti Khil	SURK R10	200	200	3	2900	1000	1.5	1. 0	0.6	-	-	-	-	-	Int Fl	0+000 1+760	2	Construction of an Intake and a smal flume are suggested.
11	Deh Balu	SURK R11	125	160	1	1700	500	1.2	1. 0	0.5	0+260	Flum	1976	Govt.	The Structure is O.K.	Cl Int	0+000	2	Cleaning of the canal and construction of an Intake are required.
12	Mirzayan	SURK R12	125	140	3	4000	2000	1.0	0. 8	0.5	-	-	-	-	-	Cl Int		2	Cleaning and Control Structure for the intake of the canal is required.

Note: For Surkhrud Command Area, Nangarhar Province (1993)

Stones should be filled to the depth of the first brace and then the bracing wires placed directly above the level of the stone making sure that the wire passes around at least two mesh widths. The same procedure should then be followed for the next layer.

In aprons downstream of weirs and in similar places where water falls directly on to the gabions or, vertical bracing wires between the top and bottom mesh must be provided. Additional horizontal bracing must be used at the corners of structures.

A.3.5.4 Crest Protection of Weirs

A concrete layer will be provided on the crest of weirs as shown on the Drawings or as directed by the Engineer to protect the gabion mesh against damage. This should be of minimum thickness of 0.10 metres and should be provided once the structure has been completed and any initial settlement has taken place. Contraction joints should be prvoided at regular intervals which should not exceed 3 metres.

A rigid capaping of concrete to gabion walls is not to be provided as this restricts the flexibility of the gabion structure. Where protection of such walls is recommended by the Engineer, as in the case of protection of theft of wire, a thickness of 0.05m should be provided. Where greater thicknesses are recommended, a flexible protection material must be used.

TABLE 1.3/continued

S. No	Name of Canal	Ref. No.	Command Area (Ha.)		No. of Village	Average Canal Details					Nature of Work Already Undertaken					Work Proposed by Beneficiaries		Priority For Rehab.	Notes
			Actual	Farmer Est.		Length (m)		Average Width (m)			Location	Type	Date	Agency	Remarks	Structure/ Activity	Station		
						Main	Branch	Start	Middle	End									
13	Zulm Abad	SURK R13	90	160	4	3000	1000	1.5	1.0	0.6	-	-	-	-	-	Cl Int		2	Cleaning and Intake structure are required.
14	Kaka Khil	SURK L01	35	30	1	1000	200	1.0	0.8	0.5	-	-	-	-	-	-		4	This is a small canal the owners themselves may lock after it.
15	Kata Pore	SURK L02	185	1000	12	9000	1800	2.5	2.0	0.8	8+325	WC	1992	UNDP	The Structure Functions Properly.	Int WC WC WC WC	0+00 2+025 -2+075 2+545 -2+575 3+975 -4+005 6+470 -6+505	2	Construction of an Intake and 4 wash Crossing are recommended.
16	Malik Mirza	SURK L03	115	560	2	4000	1500	1.5	1.0	0.6	0+125	SPW	1992		Spillway made of Gabions	Cl Int	Main canal 0+000	2	Cleaning of the canal, construction of an Intake and a Wash Crossing are required.
17	Zangar	SURK L04	210	400	3	2500	1000	1.0	-						-	Cl Int	Main Canal 0+000	1,2	Cleaning and Intake construction are required.
18	Shamsha Por Bala	SURK L05	650	700	9	4400	2000	1.5	1.0	0.5					-	Int WC	0+000 2+033 -2+105	2	Construction of the Intake and a Wash Crossing are Suggested.
19	Shamsha Por Payan	SURK L06	550	300	3	4000	1500	1.5	1.0						-	LMC Int Fl Fl	 0+000 0+ 450 0 +975	4	Land Mine Cleaning is the first priority for this canal.
20	Bayazid	SURK L07	375	400	3	2500	1500	1.5	1.0		0+500	Cul		DACAAR	397 m Culvert is under Construction by DACAAR	-		4	DACAAR deals with reconstruction of this canal.

NOTES:

* In the column of Proposal by Beneficiaries the abrevaitions stand for:

- In - Intake
- Cu - Culvert
- Fl - Flume
- Rw - Retaining Wall
- Cl - Cleaning
- LMC - Land Mine Cleaning
- WC - Wash Crossing

** In the column for Priority the numbers 1 - 4 stands for:

1. Not cleaned yet ; no water flowing, farmers present or likely to return.
2. Water flowing; canal cleaned but requires further cleaning ;Urgent structural problems (New and Rehabilitation); Farmers Present.
3. As for 2 but Less Urgent structures are Required.
4. Low priority ; No assistance recommended at present.

TABLE 1.4 EXAMPLE OF RESULTS OF INVENTORY SURVEY GIVING ALL STRUCTURES REQUIRED AND THEIR PRIORITY

No.	NAME OF CANAL	WATER SOURCE & REF. NO.	CONSTRUCTED STRUCTURES	STRUCTURES TO BE BUILT	PRIORITY FOR REHAB.	REMARKS
1	Souray	AN-R1	NIL	W.CU 2+645 - 2+646	III	-
2	Adar	AN-R2	SW. 0+230 , FL. 1+590 W.CU 2+650	IN. 0+00 -	IV	- -
3	Woloswali	AN-R3	R.CU. 0+930 W.CU. 4+032-4+097 -	W.CU 0+864 - 0+889 W.CU 1+240 - 1+260 W.CU 3+030 - 3+040 W.CU 3+850 - 3+858 R.W 3+810 - 3+650	I	CONSTRUCTED STRUCTURES SHOULD BE REPAIRED. -
4	Sakhra	AN-R4	IN. 0+00 , R.CU 2+315 R.CU 3+525 - -	W.CU 1+450 - 1+540 W.CU 3+327 - 3+380 RW. 3+380 - 3+450 W.CU 4+059 - 4+069 R.CU 4+470 - 4+476	II	R.CU 3+040 - - -
5	Kokhi	AN-R5	BP.(Gabion) 0+678 - 0+718 -	IN. 0+00 W.CU 0+761 - 0+793	III	- -
6	Rajee	AN-R6	IN. 0+00 - - -	B.P. 0+00 - 0+300 W.CU 2+118 - 2+150 FL. 2+950 - 2+955 W.CU 3+470 - 3+485	III	- - - -
7	Kanda	AN-R7	- -	IN 0+00 W.CU 0+330 - 0+356 W.CU 0+525 - 0+535	III	- -
8	Badi-ul-abad	AN-R8	SW. 0+880 - - - - - - - - - - - - -	W.CU 1+330 - 1+385 W.CU 2+114 - 2+129 W.CU 2+520 - 2+535 W.CU 2+937 - 2+970 W.CU 3+420 - 3+443 W.CU 3+925 - 3+945 W.CU 4+185 - 4+200 W.CU 4+750 - 4+770 W.CU 5+00 - 5+01 W.CU 5+323 - 5+331 R.CU 5+945 - 5+955 W.CU 7+224 - 7+230 W.CU 7+550 - 7+555 W.CU 8+285 - 8+310 W.CU 8+605 - 8+616 W.CU 8+780 - 8+789 W.CU 9+740 - 9+805	I	- - - - - - - - - - - - - -

Note: For Laghman Command Area, Laghman Province (1993)

TABLE 1.4/continued

No.	NAME OF CANAL	WATER SOURCE & REF. NO.	CONSTRUCTED STRUCTURES	STRUCTURES TO BE BUILT	PRIORITY FOR REHAB	REMARKS
9	Nahr Shahi	AN-R9	RW. 0+450 , W.CU 3+440 R.CU 4+650 , W.CU 5+300 W.CU 5+080 , W.CU 6+800 W.CU 7+915 , W.CU 9+061 W.CU 12+120 , W.CU 13+135	IN.0+000 S.P. 0+250 - 0+285 W.CU.15+240 - 15+280 - - -	II	ALL THE CULVERTS WHICH WAS CONSTRUCTED BY R.D.A 1992, ARE USELESS THERFORE SHOULD BE REPAIRED. - -
10	Bisram	AN- R10	NIL	NIL	IV	-
11	Katal (Kuri)	AN-R11	R.CU. 6+250, R.CU. 6+702	W.CU 4+758 - 4+770	III	CONSTRUCTED STRUCTURES SHOULD BE REPAIRED.
12	Armul	AN-R12	IN. 0+00 , W.CU 7+150 - -	SW. 0+713 - 0+725 SW. 1+230 - 1+235 R.CU 4+900 - 4+906	III	- - -
13	Padshahi	AN-R13	W.CU 3+425 , R.CU 5+865 R.CU 6+646 , R.CU 7+660 R.CU 7+780 , R.CU 7+810 R.CU 7+825 , R.CU 7+940 R.CU 8+020 , FL. 8+235	IN.0+000 B.P 0+400 - 0+750 - - -	III	FLUME ON STATION 8+235 SHOULD BE REPAIRED. - - - -
14	Souray Canal	AN-L1	-	-	-	-
15	Mango Canal	AN-L2	-	-	-	-
16	Nimnanay	AN-L3	W.CU 0+788 , W.CU 1+675 W.CU 2+065 , W.CU 5+00 - - - -	IN 0+00 W.CU 4+260 - 4+300 RW. 4+300 - 4+350 W.CU 4+963 - 4+972 W.CU (Branch) 4+00 - 4+050 W.CU (Branch) 4+338 - 4+365 W.CU (Branch) 7+172 - 7+180	II	R.W. 1+00. - - - - -
17	Qasaba	AN-L4	S.W 1+810 (MADERA) R.W 1+830 (MADERA) S.W 2+00 (MADERA) - - -	IN. 0+00 S.W 0+100 - 0+130 S.W 0+167 - 0+170 W.CU 2+060 - 2+215 W.CU 3+790 - 3+810 W.CU 4+48 - 4+515 W.CU 5+905 - 5+920 W.CU (Branch) 6+100 - 6+120 B.P 6+120 - 6+420	II	- - - - - 300 M. OF THE CANAL HAS BEEN WASHED BY HEAVY FLOOD, NOW THERE IS NO CONNECTION BETWEEN TWO PARTS OF THE CANAL.
18	Hakimabad	AN-L5	-	IN 0+00 W.CU 2+145 - 2+158 W.CU 2+910 - 2+925 W.CU 3+900 - 3+930	III	-
19	Nilawat	AN-L8	-	NIL		

2. SITE SURVEYS

2.1. Introduction

The surveys of existing irrigation systems should be carried out in a professional manner with the work approached seriously and data recorded in a systematic way. The quality and quantity of data collected should be carefully controlled with surveys being split in phases so that all the data are not collected at the same time and that a periodic plotting of results occurs. Deficiencies can therefore be remedied more easily and phased designs and work plans implemented.

Supervision of the surveyors by the more experienced engineers from the implementing organizations is essential to ensure that all the required data are collected at one time and that a correct assessment is made of the area that needs to be surveyed. The topographical surveys for the rehabilitation of the traditional irrigation systems comprise solely the surveys of the existing canals. This will include the following survey of canals:

- Layout of canal systems,
  - Plan Surveys
  - Inventory surveys
- Long sections,
- Cross sections,
- Details of existing features.
- Site Surveys for Structures

The survey work is undertaken to ensure that all of the assistance that is to be provided is sustainable in the long term. Future canal shapes and slopes (and hence capacities) need to be related both to the prevailing topography and existing infrastructure as well as to the established engineering criteria. The designs for both the cleaning of the canals and for the structures envisaged for the next project Phase will be based upon the data collected during these surveys. These are discussed below.

2.2. Canal Surveys

The intention of the surveys is to confirm the layout of the canal systems and to collect sufficient data to enable the long sections of the canals to be drawn up and designs produced. All data collected should be clearly recorded in site survey notebooks, copies of which must be submitted with the results of the surveys. The typical data that are required in the survey book are shown on Table 2.1. The data entered in the books must include comments and dimensions/levels for the major features already identified such as start/end of washes, location of branches, turnouts, culverts, mine areas etc., as well as other problem areas not already identified. In addition to the collection of these data, the finished bed and bank levels, bed widths and hence canal slope should also be collected for canals already cleaned so that comparison and adjustment of the designs already produced, can be made.

2.2.1. Canal Layout Surveys

These surveys usual precede the topographical surveys and the initial cleaning works and are carried out to check and confirm the canal layout map prepared during the reconnaissance mission, to mark the alignments of the main, branch and important secondary canals on available topographical maps and to identify the location of the main offtakes from these canals. The timing for the subsequent survey and cleaning work is dependant upon the results of this Canal layout Survey and thus all of the work and data plotting must be completed as soon as possible and normally within one month of the signature of the survey agreement.

The requirements of the Canal Layout Survey work is to confirm the number, length and importance of the canals in the specified Command area and to define the assistance required and the associated priorities. The surveys of the existing canals are divided into two sections. The first (PLAN SURVEY) normally takes two weeks and is aimed at assisting the production of an overall plan for assistance. This will include the following:

- Confirmation of canal names, layout and location (PLAN SURVEY),
- Identification of any work already completed, under process or planned under funding from other agencies or by the farmers themselves,

The second section (INSPECTION SURVEY) is the collection of more detailed information on each canal and requires walking down the length of all main, branch and important secondary canal. The collection of these data will assist with the prioritization of assistance required, whether it is canal cleaning, surveys or structural work.

(a) Plan Surveys

These surveys are carried out to define the canals within the command areas and also to confirm the draft layouts that have been prepared during the initial field reconnaissance surveys. In order to relate canals to commanded area, they must be carried out using the available topographical maps on which the location, length and command areas should be checked and defined. The following should be carried out:

(i) Confirm the names and approximate location of the main canals in the respective command area(s) as given during the reconnaissance surveys and indicated on the annotated 1:100,000 scale maps.

(ii) Identify and confirm the water source for each canal. This may be River, another canal, or perhaps a spring or wash water source. (note: If any of the canals are branch canals or do not have their own direct connection with the water course, this should be clearly indicated).

(iii) Estimate the length of each main, branch and important secondary canal and their current condition by walking down its length. This will assist with the determination of the order of survey priority.

(iv) Through local interviews and discussions with the farmers, assess whether any external assistance has already been provided for the cleaning of the canal and who it was funded by. (Note: if the canal has already been cleaned by the beneficiaries themselves, then this should be stated).

(v) In the case of external assistance, approach the funding agency to determine the level and nature of the assistance actually provided.

(vi) Preparation of a Canal Layout Map at 1:50,000 scale using the available 1:100,000 scale maps as the basis. All names and main features should be shown on the layout map. The extent of the irrigated area under command of each canal should also be given together with the boundaries between the different command areas. The start and end of the main, branch and important secondary canals should be clearly shown and these must be the starting points for the topographical surveys.

(vii) From the plan data, prepare a draft priority list of canals for cleaning assistance and present a recommended order of survey. This should be agreed prior to the start of the next stage of the survey work.

(b) Inspection Surveys

The requirements of the inspection survey work is to confirm the number, length and condition of the canals in designated command areas that have been defined during the plan surveys. The intention is to collect sufficient data to enable the current condition of the canals to be assessed, the problems that the farmers are experiencing defined and to identify the main features on each canal that must be recorded during the detailed topographical surveys. All data collected should be clearly recorded in site survey notebooks, copies of which must be submitted with the results of the surveys. These data should then be drawn up according to the example given in Table 2.3.

The data entered in the books must include comments and dimensions and/or levels for the major features already identified and the following should be recorded as a minimum requirement:

(i) Start of each canal. A reference bench mark must be established at the beginning of each canal at a suitable location on an immovable object. This will be used for the subsequent longitudinal surveys. The starting point for each canal should be the main river course from which the canal takes off. In the case of high and low flow intakes,

the location of each should be indicated, with the low flow intake being treated as the starting point. When the canal leaves the area that is liable to flood damage from the river or wash from which it takes its water, this point should be clearly indicated. This is regarded as the stable section of canal.

(ii) Location of any structures, including the chainage at the start and finish, either locally constructed or permanent including:

- turnouts,
- culverts,
- flumes
- siphons
- bridges
- retaining walls
- cross regulators
- intake structure

(iii) Location of natural features such as wash crossings and gullies including the chainage at the start and finish and the estimated length of structure that will be required to traverse the problem.

(iv) Condition of canals in the reaches (e.g. cleaned; silted; good cross section; narrow; etc.;).

(v) Location of main buildings and structures alongside the canal and the land use immediately alongside the canal (e.g. village; agricultural land; swamp; river course; graveyard; mine field; etc.;).

(vi) Preparation of an updated priority list for cleaning, surveys and structural work and a plan for the same based on the above information. This should also include an estimate of the time and resources required to carry out both the survey and cleaning work BY CANAL and should be finalized before the start of the topographical survey work.

(vii) Identify suitable locations for reference bench marks for each canal to be used during the topographical surveys.

(viii) Any problems that are not already identified above.

2.2.2. Topographical Survey of Canals

The purpose of the topographical surveys is to obtain sufficient data from which the canal designs can be prepared and the existing capacity related to the required full supply capacity. The priority canals for survey, whether main, branch and important secondary canal, will have been defined during the canal layout surveys and the order in which the surveys are completed should be according to this priority list and the associated work plan.

The agreement for the topographical surveys should include the collection of all data on cross sections, long sections and structures and the details must be well recorded for each canal so that they can be used for subsequent site surveys for structures on the same canals. The data that should be collected as a minimum requirement are:

(i) The alignment of each canal and its name must agree with that shown on the Canal Layout Map. If there are found to be errors, these must be clearly highlighted so that the appropriate adjustments can be made to the layout map.

(ii) Bench Marks. It is essential that good and reliable bench marks are established so that future surveys can be linked into the same grids by using the same bench marks and reference points. Temporary bench marks should be established every one to two kilometres and these should be clearly marked with a sketch map made of each site. For each canal, one permanent bench mark should be established on a suitable culvert wall or similar immoveable structure which has been identified during the Canal layout Survey. The bench mark should be marked with spray paint so that it can be easily located during subsequent surveys.

(iii) Long Sections. For the canal long sections, typical bank and bed levels should be given every 25 metres as shown below. Areas where mines are located and canal surveys are not possible must should be clearly shown and copies of the location maps given to de-mining organization immediately. In these cases, the reference bench mark must be transferred around the mined area to a safe area where the survey can be resumed. Once the mines have been cleared, the surveys should be completed and tied in with the data already collected.

(iv) The starting point for each canal should be the main river course where the canal takes off and at the point agreed during the Canal layout Survey. In the case of high and low flow intakes, the location of each should be indicated, with the low flow intake being treated as the starting point. When the canal leaves the area that is liable to flood damage from the river or wash from which it takes its water, this point should be clearly indicated. This is regarded as the stable section of canal. For Branch or Secondary canals, the point of departure from the higher level (Main or

Branch) canal should be the starting point and the chainage of this higher level canal should be shown as well as the zero chainage of the lower level canal.

(v) Data must be plotted on suitable scales using recognized drawing sizes. Horizontal scales should be 10 times the vertical scales and the following are suggested:

Horizontal scale:-	1: 1,000
Vertical Scale:-	1: 100

The axes should be clearly labelled and the notations given in table 2.1. should be used. A0 (841mm x 1189mm) or A1 (594mm x 841mm) drawing sizes should be used and these must have a title box at the bottom right hand corner and a border of about 20mm all the way round the outside.

All of the data recorded on the site plans must be shown on the long sections of the canals (e.g. offtakes, washes, culverts, mine areas etc.,). These are to be shown as a vertical line at the required chainage.

(vi) Cross Sections. Cross sections should be taken every 100 metres or at significant points in the canal where these occur between the 100 metre grid points. The data collected must correspond with that collected for the longitudinal surveys and all major points or changes in direction must be recorded. Typical ground levels 5.0 metres either side of the cross section must also be recorded indicating the land upslope of the canal and the typical level of the irrigated land down slope from the canal. Distances must be measured in metres left or right from the centreline of the canal. The data that are required are illustrated in the drawing below:

One typical cross section should be plotted every 500 metres on graph paper using the same vertical and horizontal scale.

(vii) Trees and Shrubs. During the survey works, the removal of mature trees and shrubs should be avoided. If it is considered necessary, then prior approval from the Engineer must be obtained. All trees and shrubs to remain in place shall be protected from damage.

2.2.3. Site Survey for Structures

Immediately after the longitudinal topographical surveys have been completed, detailed topographical surveys at each of the sites identified as needing the construction of structures to overcome the problems that the farmers are experiencing. These detailed site surveys should be carried out to ensure that the structures are located in the correct place and at an elevation that will neither restrict flow

ACBAR (MR MACFADDEN)

FOOD AND AGRICULTURE
ORGANIZATON
OF THE UNITED NATIONS

اداره خوراک و زراعت اوام متحده

PROGRAMME FOR REHABILITATION OF AFGHANISTAN AGRICULTURE

(See Distribution List).

May 23, 1994

Dear Sirs

DESIGN MANUAL
for the Rehabilitation of Informal Irrigation Systems in Afghanistan

Following the completion of the irrigation workshop held in Peshawar on 1st and 2nd November 1993, we have pleasure in enclosing the Final draft of the Design Manual. This is being issued to all those who participated in the Irrigation Workshop and also those NGOs who are acting or have acted as implementing partners for FAO. We would be grateful if you would circulate the manual to those members of your organization who attended the workshop and also those members of your organization who are involved in the Rehabilitation of Informal Irrigation Systems in Afghanistan.

At a later date, FAO intends to have this manual translated into Dari and Pashtu, but at present the Manual is presented in English. Most of the target group of Engineers and designers are in fact fluent English speakers and readers and this should not therefore present a problems in its use.

A manual such as this is never complete and there are always comments and additions that are required with time. I would however like to make the following comments and caveats for those who use the manual.

1. The Manual is formulated with the Informal Irrigation Systems in Afghanistan in mind. There will of course be differences from area to area, but with careful use of the contents and the way in which it is presented, all users will find something of value in the manual.

2. The policy that has been adopted under the irrigation component of the FAO Programme for the Rehabilitation of Afghanistan Agriculture is that of long term sustainability of interventions. This derives from the essential transition that occurs from relief to rehabilitation to development and is reflected in the methodology adopted and the designs presented. Structures that are beyond the maintenance capability of the local beneficiaries have been avoided except where to replace existing structures would have been either too costly or inappropriate.

3. The rehabilitation process has identified those requirements that are either essential to encourage the beneficiaries to return to their previously cultivated lands or which are beyond the temporary or permanent resources of the rural communities.

4. Whereas the designs and approaches can be utilised with adaption to small and large schemes alike, they have been directed at the larger command areas where a systems approach is required and where errors in slope, canal capacity etc. will have the greatest detrimental impact.

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through the canal nor through the wash or feature through which the structure passes.

The site surveys should be implemented as part of a phased plan so that designs can be prepared for one site whilst field data are being collected for another. It is essential that as soon as the site data have been collected from one site, the data are sent to the design office for plotting so that a site plan and map can be produced. These will be required by the design Engineers to produce the draft designs for the structure.

The following should be borne in mind when drawing up agreements for the site surveys to ensure that sufficient data are collected:

(i) Where washes are to be crossed, long sections should be taken of the wash for sufficient distance upstream and downstream of the crossing point. This is to enable estimates to be made of the long slope of the wash, the possible future scour slope and the in-bank capacity of the wash.

(ii) The surveys should be taken on a square grid (5.0 m x 5.0 m) utilizing the same bench marks as were used for the longitudinal surveys.

(iii) All of the main features of a site must be identified (banks; wash limits; etc;) as well as possible alternative locations for the structures. For example, in the case of washes/ gullies, the existing crossing points of the canals as well as the areas upslope should be included so that suitable alternative crossing points can be identified.

(iv) The site plans should be accompanied by long sections of the gullies so that the slope(s) can be identified not only to confirm whether the gully/wash is increasing or decreasing in level at the crossing point, but also to enable the runoff at the site to be estimates using the manning formula.

(v) The data collected should be plotted onto a topographic map prepared for the site and the results should be compared with the longitudinal surveys to ensure that they can be connected and there are no errors.

Field recording of the site data and the presentation of the results should follow the same standards as set out earlier for the other surveys.

TABLE 2.1

SAMPLE OF SITE SURVEY BOOK

Date :					Survey Team:	
Canal:						
Location: From:					To:	
Back Sight	Inter-mediate	Fore Sight	Height of Collimation	Reduced Level	Distance	Remarks

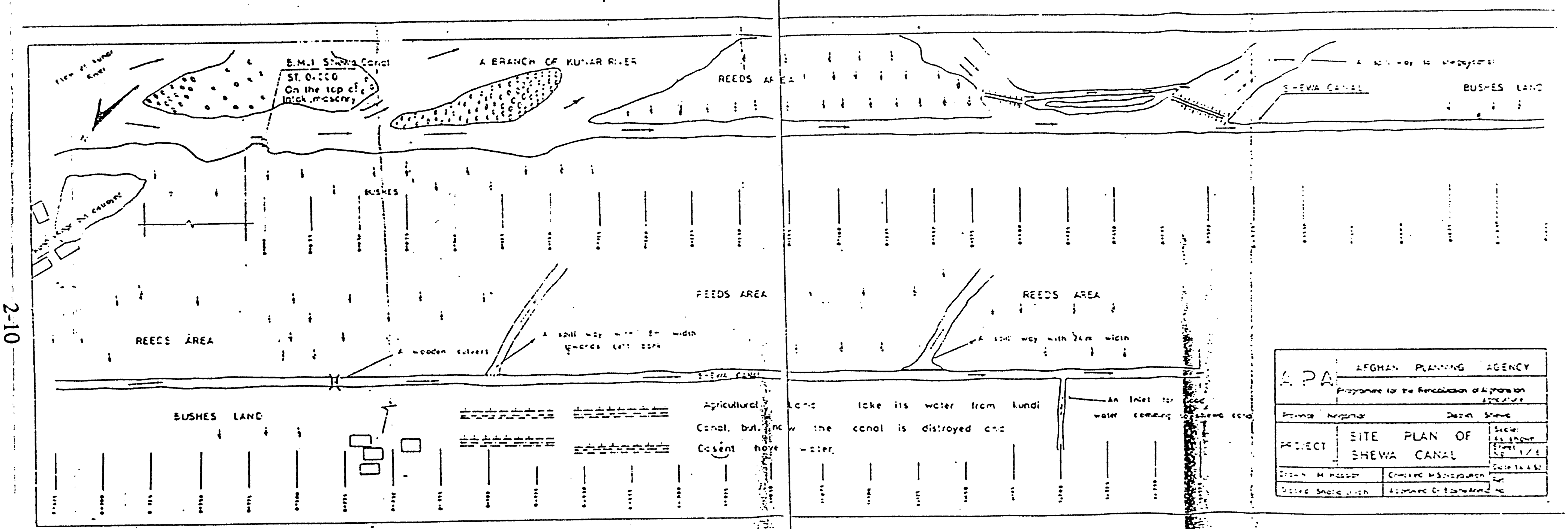
TABLE 2.2

NOTATIONS TO BE USED IN THE PLOTTING OF THE RESULTS
OF THE CANAL LONG SECTIONS

DISTANCE (Metres)			
- Partial	25	25	25
- Cumulative			
EXISTING CANAL LEVELS (Above datum)			
- Left Bank			
- Bed			
- Right Bank			

TABLE 2.3

EXAMPLE OF RECORDING THE RESULTS OF THE INVENTORY SURVEY



3. CANAL DESIGN

3.1. Procedure

Following on from the reconnaissance and topographical surveys, the next step is to ensure that the capacity of the canals is sufficient to provide adequate water to all of the land commanded. Earlier studies carried out before the start of hostilities concluded that the areas that were then commanded probably represented the maximum areas that could reasonably be irrigated by gravity. This does not mean that all of the areas received sufficient water, but that it was not physically possible to extend the gross commanded area. In the assessment of design capacities, it is thus important to identify the gross areas that would be supplied by the cleaned and improved canals.

To determine the dimensions of the main canals for all areas to be assisted, the longitudinal survey data from the topographical surveys carried out must be assessed in detail. The data must be plotted to show the proposed levels to which the canals would be excavated, the slopes that would be adopted and the head losses across structures and other important features that already exist. Onto these sections, the new longitudinal sections should be superimposed and excavation requirements estimated. Bank levels should be sufficient to pass the design discharges (see below) and where canal slopes resulted in excessive velocities, these should be adjusted to reduce to a minimum the amount of extra excavation.

Once the field survey data have been received, it is essential that they are examined and checked in detail in the design office. The following checks are recommended:

(a) Check the layout and names of all of the canals in the command area as compared with the original plan prepared before the survey agreement;

(b) Define the route of the main canal and the location of each offtake for the branch canals from the main canal;

(c) Define the command areas for each main and branch canal;

(d) Note locations at which the section of the main canal can be changed and excess water spilled;

(e) Examine the survey plan and notes in detail to see whether problems areas (mines; bank erosion; wash crossings; etc.;) and the location of existing structures (either local or more permanent) have been identified. Also the locations of all offtakes from the main canal whether to branch or smaller canals should be noted;

(f) Feed the survey data into the standard design spreadsheet to see whether there are any

obvious anomalies (e.g. steep sections of canal; excessive bank heights or canal excavation; etc.;);

(g) Examine the cross sections presented against the survey data to see that they have been drawn correctly;

(h) From these cross sections estimate the average bed width for the different sections of canals;

(i) Complete a first design of the canal using the survey data and the bed widths and command areas supplied by each canal as defined in (b) and (c) above;

(j) Check the water and bed levels at each offtake (branch and other) identified during the field surveys to ensure that the land to be irrigated by them is still under command;

(k) From the designs, identify areas with obvious anomalies or where queries exist. Discuss the findings with the surveyors from the NGOs.

(l) Field check the data with the NGOs surveyors before the contracts are signed examining the points identified under (j) and (e) above as well as carrying out other spot checks;

(m) Adjust the designs according to the findings of the field checks and request the NGO to provide checks or further data if considered necessary;

Once the canal designs have been produced, they need to be field checked so that the design levels can be compared with the actual levels and slopes. In addition, the main dimensions of washes, culverts and other major structures and features through which the canals pass should be checked against the original survey data. The estimated location of branch canals, areas commanded by each section of canal and required water levels at each offtake should also be checked.

When the canals are initially cleaned, the farmers will tend towards the original canal width. When the final designs are produced, these widths should be adopted wherever possible, with the increased capacities being achieved through changes in depth and canal slope.

Once the data on canal water levels have been derived from the above and the requirements of the identified structures (both existing and planned) have been determined, the final canal designs can be produced. These will need to be some initial assumptions relating to head loss across the structures and in chapter 5, estimates of the order of magnitude that should be adopted are given.

3.2. Canal Design

The canals that are found in the traditional irrigation systems in Afghanistan are all unlined earth

canals. These have been constructed many years ago and were cleaned annually by removing by hand deposited and hill wash material. Due to the neglect to this maintenance during the war period, considerable amounts of deposited river silt and hill wash material have accumulated.

Canals capacities vary from a few litres a second in the steep highland areas like Kamdesh in Kunar up to several cubic metres per second in the Lower Kunar and Arghandab right bank command areas. The systems were originally developed by the farmers themselves with little to no external assistance, solving the problems of shape and slopes through trial and error. In the steeper lands efficiency of canal design has not been important as head/command is not normally a problem. In the flatter lands these considerations are more important, particularly in the larger irrigated areas where land slopes can be considerable less than the river slopes.

Many organizations become involved in cleaning and repairing the canals as this is regarded as a visible way of showing relief and is considered simple and non technical. As long as the local Mirab[1] is consulted and the canals are cleaned to their original width, then the approach adopted is suitable for over coming the initial water shortages. In these cases the canal slopes and sections adopted have been those that the farmers felt had existed before they had fallen into disrepair. It has been found that they had often underestimated the amount of silt that had collected in the canals as they had never been faced with this situation before.

To assist in future cleaning exercises, and also to assess the size of the structures to be constructed on the canals already cleaned, the following general canal design criteria are presented. It is hoped that these will be of assistance to all organizations cleaning canals of traditional irrigation systems in Afghanistan. Although in some cases one contour canal supplying lower canal systems would appear to be the better solution, this does not comprehend the complex water distribution and allocation systems that have derived with time. Considerable care must therefore be exercised when planning changes to canal systems during rehabilitation. It may be possible to make minor adjustments to canal alignment and slope, but evidence has already shown that the farmers are only prepared to accept very minor changes before conflicts arise.

3.3. Design Duty

Estimates of design duty have been made using two models, one the Kunar river basin in the Kunar and Nangarhar Provinces, where perennial water supplies exist, and the other the Shamal river basin in Eastern Paktia where the river flows are predominantly seasonal. As no recent data are available, crop water requirements have been taken from 1977 data.

For areas where water is not considered to be a constraint, it can be assumed that irrigation is practiced mainly during daylight hours, with night time flows being used for water mills, domestic

1 Traditional village water master

and other community uses. In these conditions, an overall project efficiency of 0.41 (see below), a gross to net ratio of 0.85, a flexibility factor of 1.15 are reasonable and these give a specific discharge of 3.1 l/s/ha (gross). This value is suitable for dimensioning of both the main canals and their structures within the larger systems where a mixed cropping pattern including vegetables, rice and sugarcane, is practiced. It should not however be applied directly to the secondary or tertiary canals as their capacities will depend upon the period and system of rotation adopted.

In the areas where supplies of water are not reliable during certain seasons, irrigation will be practiced on a continuous basis. Although this tends to result in a canal with a smaller cross section, this should not be followed as the canals need to be "oversized" so that additional water from other canal systems or flash floods in the river, can be introduced into the systems to compensate for drought periods. It is thus proposed that the specific discharge derived above should be used for both scenarios.

Set out in the following sections are the main details that should be considered when assessing canal design duty.

3.3.1. Crop Water Requirements

Crop water requirements have been taken from the estimates made in 1977 that were derived using Blanney Criddle method and utilizing climatic data that were available at that time. Values for each main area are given in Tables 3.9 to 3.28. These are by no means definitive, but should be utilized in the absence of more precise site specific data.

3.3.2. Canal Efficiency

To account for the losses of water during conveyance from the rivers to the fields, an efficiency factor needs to be included in the calculation of project/ area water requirements. This enables the capacity of the canals at given points to be determined when designing structures.

The efficiency is made up of two components:

Distribution Efficiency (Ed)
Field Application Efficiency (Ea)

The **Distribution Efficiency (Ed)** itself comprises two components:

Conveyance Efficiency (Ec)
Field Canal Efficiency (Eb)

Distribution Efficiency is the product of these two and thus

$$Ed = (Eb) \times (Ec)$$

Considering the canals within Kunar and the earlier studies the following estimates have been made:

Conveyance Efficiency (Ec)	= 0.90
Field Canal Efficiency (Eb)	= 0.70
Hence Distribution Efficiency (Ed)	= 0.90 x 0.70
	= 0.63

With the problems that are experienced in crossing the washes and gullies on most of the irrigated areas, the actual values of conveyance efficiency are probably much less than this. However the objective of the canal improvements is to overcome these problems and thus the above values are considered appropriate for design of the structures.

The **Field Application Efficiency (Ea)** is the ratio of the water made directly available to the crop and that released into the canal system. It will depend upon irrigation methods and the soils to be irrigated. The earlier estimates (Ea = 0.65) were based upon detailed soils surveys carried out at that time and are still considered to be reasonable. These have thus been adopted here.

The **Project Efficiency (Ep)** thus becomes:

$$\begin{aligned} Ep &= Ea \times Eb \times Ec \\ &= Ea \times Ed \\ &= 0.65 \times 0.63 \\ &= \underline{0.41} \end{aligned}$$

3.3.3. Design Duty

From the data presented above, a specific discharge of 1.3 - 1.6 l/s/ha (net) derives. To allow for flexibility, it was recommended that this was increased by 30%[2], particularly considering that the level of management was not as high as it was before the war. This gave a value of 2.1 l/s/ha (net). In 1977 the ratio of gross to net area was estimated as 1.0 : 0.85. When the areas are brought back into full production, this will probably still apply. Thus using this figure the specific discharge that derives is:

$$= 2.1 \times 0.85 \text{ l/s/ha}$$

[2] Irrigation Development in Kunar Province, Afghanistan, Technical Reconnaissance Mission, I. McA. Anderson, Agrisystems (Overseas) Ltd., December 1989

$$= \underline{1.8 \text{ l/s/ha (gross)}}$$

Irrigation is practiced in daylight hours except where water quantities are limited, which is normally the case at the ends of the canal systems or in years of exceptional low river flows. Although the canals flow continually, rotation between secondary and tertiary canals is practiced. Thus although the specific discharge is suitable in determining the 24 hour water requirements, it under estimates the capacity of the main canals.

Assuming that irrigation is practiced only during daylight hours and that the specific flow is 1.6 l/s/ha, then the capacity of the main canal would be given by:

$$Q = (1.6 \times 24/12 \times 0.85) \times C \quad \text{l/s/ha (gross)}$$
$$= 2.72\ C$$

where:

C = Flexibility factor that allows variation in future cropping patterns and intensities

The value of C normally varies between 1.1 and 1.4 depending upon the size and type of system. A value of 1.15 has been adopted in the designs.

Thus:

$$Q = 2.72 \times 1.15$$
$$= 3.1 \quad \text{l/s/ha (gross)}$$

At times of low flow or peak demands, some areas will irrigate during the night. This will permit greater flexibility to the levels that were assumed in the last report (Anderson; 1989) when the flows were increased by 30%.

For the dimensioning of both the canals and the structures within the larger command areas, the value of 3.1 l/s/ha applied to the gross area should be thus used. This value should not however be applied directly to the secondary or tertiary canals as their capacities will depend upon the period and system of rotation adopted.

3.4. Canal Longitudinal Slopes

For the cleaning of the canals, uniform longitudinal slopes that fit as close as possible with the existing surveyed slopes should be proposed. In most cases these will be adequate, but must be related to command, cross section shape, velocity and hence capacity. In some places, slopes are locally steep or extremely flat in order to command high plots of land. It is possible that with natural siltation, the locations with steep sections will naturally adjust themselves. For the others, further assistance at a later date may be required. Long surveys of the canals are taken to identify areas where such

5. The aspect of drainage is covered in Chapter 9 of the manual. This component is key to the success of any irrigation development and must not be forgotten. In most of the informal irrigation systems encountered in Afghanistan, drainage is provided by the lower canals in the system which combine to act as both conveyor and evacuator. They operate to lower the water table and also to intercept subsurface flow. In those cases where drainage is a problem in these systems, some form of drainage canal has normally existed in the past. The design of these are covered in the manual. In some cases, new drainage systems are required but these generally relate to either a temporary build up in water table, due to over irrigation resulting from the failure to achieve the level of development and cropping intensity that existing before the war, or to the reclamation of land that had never been cultivated previously (and hence included under development and not rehabilitation). Except for sub-surface drainage systems as encountered and needed in systems such as the Helmand Valley system in southern Afghanistan, the approach provided in the manual should suffice.

6. Details such as beneficiary participation and health are not covered in this **Rehabilitation** manual but will be included in later editions. It does however go without saying that all interventions require close discussion at all stages with the beneficiaries, as has been the FAO process, and the slow start proposed with the inventory and topographical surveys and planning has proven to be essential in the discussion process as it gives time for the beneficiaries to make their views known and for the Implementing Partners to establish a rapport with the rural communities. Many of the "key" farmers are not those represented on the Shuras or influential in the community and who thus require time to make their views known.

7. Unit costs have been presented in the Manual to indicate the methodology adopted. In a number of cases these will no longer be valid and care should thus be exercised when using them. A base date for the costs can be considered as mid 1993.

The next stage in Training component of the FAO Programme for the Rehabilitation of Afghanistan Agriculture is the production of a **Manual for Field Construction Staff**. This will be started with the introduction of the planned FAO programme for the existing FAO project areas of Laghman, Nangarhar and Eastern Paktia and its expanded programme in Herat. Any contributions or suggestions for this manual would be warmly welcomed.

If there are any queries, suggestions or further comments on this Design Manual, please do not hesitate to contact myself or Mr Qaseem Naimi at the FAO office in Peshawar. I will be working here on the programme until 20th June 1994.

Yours faithfully

Ian McAllister Anderson
FAO Irrigation Consultant

cc. Anthony Fitzherbert, Programme Coordinator
M Q Naimi, FAO/AAR Irrigation Engineer
~~Mr Ismet Hakim, FAO Res. Rep.~~
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problems exist. Where excessive velocities derive, the slopes must be adjusted down. In addition, where the width of the canal is not uniform and there has been no apparent reason for changing it, a constant bed width should be adopted. Design velocities should be kept where possible in the range of 0.20 m/sec to 0.70 m/sec. The actual design velocity should be selected from siltation considerations, however, in practice there is often very little scope for changing the velocity that derives from cleaning the canal to its original section and slope.

3.4.1. Available Velocity

The available velocity depends on many factors: soil material, amount of discharge, depth and curvature of canal etc., The acceptable velocities used in the design for earth irrigation canals are presented below. As command is often a problem, in some canals velocities fall below these values. These are evidenced by excessive siltation. In most cases however, except in the initial canal reaches, velocities lie in the range 0.25 to 0.50 m/sec. The table below suggests suitable design velocities for earth canals in traditional Afghan irrigation systems. Consideration should normally be given to the type of material through which the canals pass and this has been taken into account when determining the design velocities.

Table 3.1 Design Velocities for Earth Irrigation Canals

Design Discharge in m^3/sec.	Design Velocities in m/sec.
0.15 - 0.30	0.30 - 0.32
0.30 - 0.50	0.32 - 0.35
0.50 - 0.75	0.35 - 0.38
0.75 - 1.00	0.38 - 0.40
1.00 - 1.50	0.40 - 0.43
1.50 - 3.00	0.43 - 0.50
3.00 - 4.50	0.50 - 0.58
4.50 - 5.00	0.58 - 0.60

3.5. Canal Section

Although certain relationships between the design parameters are desirable, in practice, the section and slope adopted will depend upon the local conditions and the results of the cleaning exercises. In

all designs, a side slope of 1:1 has been assumed, although there are indications that steeper slopes have been adopted as the farmers were reluctant to change from their earlier practices.

Bed widths that have derived from canal cleaning should be adopted where possible. Where these have not been consistent, minor adjustments will need to be made. Freeboard has been related to water depth derived using the Manning formula.

3.5.1. Side Slopes

To limit excavation and the need to acquire additional land, canal side slopes are designed as steep as possible. Soil material, depth of the canal and the occurrence of seepage will determine the maximum steepness for a stable side slope. The minimum slopes in cut for earth canals for various soil materials are given in Table 3.2 below, and the minimum slopes for earth canals constructed with well compacted cohesive materials are shown in Table 3.3.

Before the war, canal slopes were in many places steeper than this however the stability was maintained by trees, bushes and vegetation along the canal banks. Because in many instances, water has not flowed through these canals for several years (as much as 14 years in some cases), it is necessary to revert to the theoretical design slopes dictated by the depth of excavation and the soil types. For design purposes,the following have been generally used.

$$Q < 1 \text{ m}^3/\text{s}, \qquad m = 1:1$$

$$1 \text{ m}^3/\text{s} < Q < 5 \text{ m}^3/\text{s}, \qquad m = 1:1.5$$

In practice it is extremely difficult to get the farmers to construct canals with flat side slopes and values of m of about 1:0.25 or 1:0.5 actually derive.

Table 3.2 Minimum Side Slopes for Various Soils

Soil Material	Side Slope Range 1:m
Rock	< 0.25
Stiff Clay, Loam, Loesses	1 - 2
Sandy Clay, Cohesive	1.5 - 2.5
Silty Sand	2 - 3

Table 3.3 Minimum Side Slopes for Canals in Well Compacted Fill

Water Depth + Freeboard D(m)	Minimum Side Slope
D < 1.0	1:1
1.0 < D < 2.0	1:1.5
D > 2.0	1:2

Flatter slopes than mentioned in the tables should be used for situations were seepage into the canal is expected. For embankments higher than 3 metres, a berm should be constructed of at least 1 metre width (every 3 m). For the outside slope, a berm, if needed, should be situated midway between top and foot of the embankment.

3.6. Canal Capacities

The capacity of the canals will be determined by the system of delivery adopted and the areas commanded. As data on these are generally not available at the time of designing for the rehabilitation, estimates should be made assuming that certain reduction in size will occur after the intersections of the major branch canals and large wash crossings. These canals are generally marked on the 1:100 000 scale maps and the assumptions should then be compared with the topographical survey results as these tend to indicate when there has been a marked reduction in cross sectional area.

The design discharge adopted for each reach is then taken as the product of the gross area measured from the topographical maps multiplied by the specific discharge derived under 3.1 above. In Table 3.8, an example of how this is applied to one reach of canal is given.

The Manning formula should be used to determine the capacity of all canals. A value of Manning's "n" of 0.027 has been adopted throughout for earth canals under normal operating conditions. Where concrete lining is used, a value of 0.017 should be adopted and for gravel sections at the start of the canals at the intakes, a value of 0.030 is appropriate.

3.6.1. Canal Design Formula

The Manning formula, which is empirical, is the basic flow equation for the design of open channels and has been utilized here. In its usual form it is:

$$v = R^{2/3} \cdot I^{1/2} \cdot n^{-1}$$

where:

v	=	flow velocity in m/sec.
R	=	hydraulic radius in metres
	=	A/P
A	=	wetted cross-section in m^2
		= $(b+zh)h$
P	=	wetted perimeter in metres
		= $b + 2h.(1+z^2)^{1/2}$
b	=	bottom width in metres
h	=	water depth in metres
z	=	side slope 1 vertical : z horizontal
I	=	energy gradient (canal slope)
n	=	roughness coefficient (Manning)
k	=	Strickler roughness coefficient ($m^{1/3}/s$)
		= $1/n$

Q	=	canal discharge in m^3/s
	=	$v \cdot A$
	=	$x \cdot h$
x	=	ratio between bed width and water depth depending upon the cross section

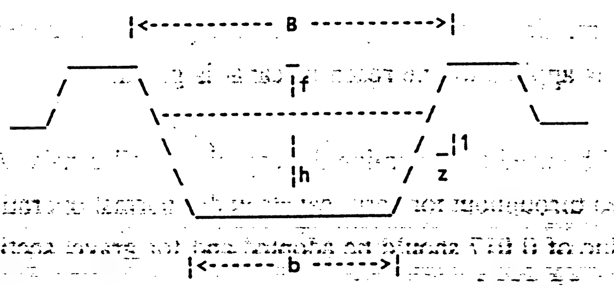


Figure 3.1 Cross Section Parameters

3.6.2. Roughness Coefficient

The roughness coefficient depends on the roughness and irregularity of the canal surface, alignment, vegetation, sediment concentration etc. The roughness coefficients for unlined earth irrigation canals are shown in Table 3.4.

Table 3.4 Strickler Roughness Coefficient(k) for Earth Canals

Design Discharge in m^3/s	Roughness Coeff. (K) in $m^{1/3}/s$
5 < Q < 10	42.5
1 < Q < 5	40
Q < 1	35

3.6.3. Bed width to Water Depth Ratio

The most efficient hydraulic section is that with the minimum wetted surface area. In practice other considerations such as cost, command and depth of excavation have to be considered. From experience, generalized values for the ratio of bed width to water depth for irrigation canals can be used. These depend upon discharge, soil type, side slope and canal roughness factor K. The design values that have been recommended are shown in Table 3.5 below.

Table 3.5 Canal Characteristics Used for Earth Canals

Discharge in m^3/sec	Side Slope 1:m	Ratio b/h	Roughness k	Factor n
0.15 - 0.30	1.0	1.0	35	0.029
0.30 - 0.50	1.0	1.0 - 1.2	35	0.029
0.50 - 0.75	1.0	1.2 - 1.3	35	0.029
0.75 - 1.00	1.0	1.3 - 1.5	35	0.029
1.00 - 1.50	1.0	1.5 - 1.8	40	0.025
1.50 - 3.00	1.5	1.8 - 2.3	40	0.025
3.00 - 4.50	1.5	2.3 - 2.7	40	0.025
4.50 - 5.00	1.5	2.7 - 2.9	40	0.025

As was the case for the side slopes above, the current cleaning and excavation works have been based on past maintenance practices. Much wider and shallower canal sections have thus resulted. At this stage it has not been recommended that this is changed, however for future works, it should be considered more. It must however be emphasized that this must not been done without considering the land to be commanded (see below).

3.7. Water Level at Turnout To Tertiary Blocks

The required water level at the outlet to the tertiary block is calculated from the level of the land to be commanded with an allowance for head loss through the structures and canals through which the water has to pass. At rice field a command of 0.15 metres above the land level is normally allowed to account for the maximum water layer on the field (under rice) and the head loss in the canal to the field. Other allowances can be generalized as:

Turnouts/ divisions at field level	=	0.05 m
Other Turnouts/ divisions	=	0.10 m
Head loss in culvert	=	0.05 m

These must also be related to the anticipated maximum and minimum water levels in the canals.

In practice, smaller heads only may be available, but it is essential to ensure that when canals and structures are modified or provided that land that is intended for irrigation can be adequately commanded.

3.8. Freeboard

Freeboard is applied to allow for an increase in the water level above design water level, also called full supply level. Minimum freeboard applied to earth irrigation canals are shown in Table 3.6.

Table 3.6 Minimum Freeboard for Earthen Irrigation Canals

Q in m^3/s	Freeboard in m
< 0.5	0.40
0.5 - 1.5	0.50
1.5 - 5.0	0.60

3.9. Bank Top Widths

For the purposes of operation, maintenance and access, embankments along the canals should have minimum a minimum width so that damage and erosion of the canal bank is avoided. Recommended minimum widths are given below.

Table 3.7 Minimum Embankment Width

Design Discharge in m³/s	Minimum Embankment Width (m)
Q < 1	1.00
1 < Q < 5	1.50

3.10. Radius of Curvature

The maximum radius of curvature of the centre lines of the canals should be $7 W_s$, where W_s is the surface water width in metres.

TABLE 3.8 EXAMPLE
DESIGN FOR CANALS IN LOWER KUNAR VALLEY

Country : AFGHANISTAN
Project Number: UNO/AFG/102/UNA
Project Title : PROGRAMME FOR THE REHABILITATION OF AFGHANISTAN AGRICULTURE

Canal: Nurgal
River: Konar (Right Bank)

Dist. (m)	Elevation Metres L.Bank	Elevation Metres Bed	Elevation Metres R.Bank	Av.Bank Level (m)	Av. Depth (m)	Average Slope (m/m)	Design Slope (m/m)	Bed Width (m)	Des.Bed Elev. (m)	Des.Bank Elev. (m)	Water Depth (d)	Total Depth (D)	Design Disch. (m3/s)	
200	99.36	98.95	100.63	100.00	1.05			1.00	98.65	99.85	.79	1.20	.78	
500	100.89	99.25	100.65	100.77	1.52	-.0010	.00067	1.00	98.45	99.65	.79	1.20	.78	
1,000	99.40	98.21	99.29	99.35	1.14	.0021	.00067	1.00	98.12	99.32	.79	1.20	.78	
1,500	99.27	98.24	99.36	99.32	1.08	-.0001	.00067	1.00	97.78	98.98	.79	1.20	.78	
1,800	98.91	97.22	98.31	98.61	1.39	.0034	.00067	1.00	97.58	98.78	.79	1.20	.78	) Chinar Wash
2,000	98.72	97.73	99.43	99.08	1.35	-.0026	.00067	1.00	97.45	98.65	.79	1.20	.78	
2,500	97.90	97.33	98.06	97.98	.65	.0008	.00039	1.00	97.26	98.61	.91	1.35	.78	
3,000	98.37	97.27	98.25	98.31	1.04	.0001	.00039	1.00	97.06	98.41	.91	1.35	.78	) Titak Wash
3,300	98.05	97.38	98.11	98.08	.70	-.0004	.00039	1.00	96.95	98.30	.91	1.35	.78	
3,500	98.98	97.53	99.43	99.21	1.68	-.0008	.00088	1.00	96.77	97.91	.74	1.14	.78	
4,000	96.79	95.63	96.94	96.87	1.24	.0038	.00088	1.00	96.34	97.48	.74	1.14	.78	
4,500	97.70	96.13	96.72	97.21	1.08	-.0010	.00088	1.00	95.90	97.38	.74	1.14	.78	
4,900	97.28	96.13	97.20	97.24	1.11	.0000	.00020	1.00	95.82	97.38	1.08	1.56	.78	) Patan Wash
5,000	97.12	96.15	96.86	96.99	.84	-.0002	.00020	1.00	95.80	97.36	1.08	1.56	.78	
5,500	97.07	96.42	97.43	97.25	.83	-.0005	.00020	1.00	95.70	97.26	1.08	1.56	.78	
6,000	96.82	96.58	97.25	97.04	.46	-.0003	.00020	1.00	95.60	97.16	1.08	1.56	.78	
6,200	97.24	96.12	95.50	96.37	.25	.0023	.00020	1.00	95.56	96.96	.95	1.40	.60	) Mazar Wash
6,500	96.94	96.21	97.03	96.99	.78	-.0003	.00020	1.00	95.50	96.90	.95	1.40	.60	
7,000	96.29	96.25	96.81	96.55	.30	-.0001	.00070	1.00	95.15	96.21	.68	1.06	.60	
7,500	95.06	94.31	95.11	95.09	.78	.0039	.00190	1.00	94.20	95.37	.52	.85	.60	
8,000	95.62	94.78	95.09	95.36	.58	-.0009	.00027	1.00	94.07	95.37	.87	1.30	.60	
8,500	96.24	94.46	96.03	96.14	1.68	.0006	.00027	1.00	93.93	95.23	.87	1.30	.60	
9,000	95.05	94.38	95.45	95.25	.87	.0002	.00027	1.00	93.80	95.10	.87	1.30	.60	

= Bed width as given to NGO for Canal cleaning

= Design slope as taken from Long section ... and given to NGO for Canal cleaning works.

= Average slope between this and previous station = (95.63 − 96.13) / (4500 − 4000)

= Taken from Canal hydraulic design on page (b)

= As above →

DESIGN OF TRAPEZOIDAL UNLINED CHANNELS (By MANNINGS)
(n = 0.027)

FROM TABLE (a)

Design Flow (Q) (l/s)	Bed Width (b) (m)	Water Depth (h) (m)	Side Slope (m)	Wet. Area (A) (m2)	Wetted Perim. (P) (m)	Hydr. Radius (A/P)	Long. Slope (S) (m/m)	Water Vel. (V) (m/s)	Froude Number (F)	Free-Board (f) (m)	Total Depth (D) (m)	Top Width (B) (m)
780	1.00	.79	1.00	1.41	3.23	.5760	.00067	.55	.20	.41	1.20	3.40
785	1.00	.91	1.00	1.74	3.57	.6184	.00039	.45	.15	.44	1.35	3.70
780	1.00	.74	1.00	1.29	3.09	.5575	.00088	.61	.23	.40	1.14	2.27
783	1.00	1.08	1.00	2.25	4.05	.6745	.00020	.35	.11	.45	1.55	4.12

TABLE 3.9

BAGHLAN

Consumptive Use Major Crops (mm)

[illegible]	Wheat	Cotton	Sugar [illegible]	Corn	Melons	[illegible]	[illegible]
Jan	4					14	
Feb	18					22	
Mar	33					53	53
Apr	131				28(½)	96	90
May	204	38	78		113	[illegible]	169
June	160	85	146	109	166	[illegible]	235
July		185	215	198	166	256	256
Aug		198	232	213		209	209
Sep		122	167	130		136	136
Oct		54	97			78	79
Nov	17					32	19
Dec	9					16	
TOTAL	632	682	935	650	473	1318	1246

TABLE 3.10

BAKTYAN

Consumptive Use Major Crops (mm)

Month	Wheat	Potatoes	Barley
Jan			
Feb			
May			17(½)
Apr	76		76
May	114		156
June	110	34	120
July	48	113	27
Aug		154	
Sep	36	154	
Oct	50		
Nov			
Dec			
TOTAL	434	455	396

IRRIGATION DESIGN MANUAL
Distribution List.

1. AFS
2. ACA
3. ACBAR
4. ACLU
5. ACRU
6. AEA
7. ARC
8. ARF
9. ARR
10. ARCAR
11. APWO
12. ARIA
13. BCURA
14. CARE International
15. CIUP
16. CBR
17. DACAAR
18. EDS
19. HRP
20. IHSAN
21. IMRAN
22. IRC
23. ISRA
24. JCE
25. MADERA
26. MAWA
27. MEMAR
28. NPO
29. NCA
30. RAFA
31. RAH
32. RDA
33. RDM
34. RPA
35. RSSA
36. SCA
37. SJAWO
38. START
39. TPRPA (Now SAFA)
40. UNDP/OPS (Peshawar) - Engineering Section
41. UNDP/OPS (Peshawar) - Irrigation Consultant
42. UNDP/OPS (Islamabad)
43. UNDP/OPS (Mazar Sharif)
44. UNDP/OPS (Quetta)
45. UNDP/OPS (Quetta) - Irrigation Consultant
46. UNDCP (Peshawar)
47. UNOCHA
48. UNDP Res. Rep. Afghanistan
49. UNDP Res. Rep. Pakistan
50. VITA
51. WRC
52. YARA

TABLE 3.11

FAIZABAD

Consumptive Use Major Crops (mm)

Month	Wheat	[illegible]	[illegible]
Jan			
Feb			
Mar	67		
Apr	103	18(½)	82
May	130	87	129
June	51	162	156
July		249	229
Aug		66	199
Sep			123
Oct	19(½)		68
Nov	45		
Dec			
TOTAL	415	582	986

TABLE 3.12

FARAH

Consumptive Use Major Crops (mm)

Month	Wheat	Cotton	Corn	Melons	Alfalfa
Jan	35				
Feb	61				38
Mar	115				83
Apr	189	20(½)		61	133
May	272	85		133	219
June		196	140	206	295
July		300	249	101(½)	325
Aug		252	272		266
Sep		141	166		174
Oct		42			107
Nov	12(½)				50
Dec	25				
TOTAL	710	1036	827	501	1690

TABLE 3.13

GARDEZ

Consumptive Use Major Crops (mm)

Month	Wheat	Barley
Jan		
Feb		
Mar		
Apr	79	
May	125	45
June	147	140
July	33($\frac{1}{2}$)	210
Aug		133
Sep		10($\frac{1}{2}$)
Oct	2($\frac{1}{2}$)	
Nov		
Dec		
TOTAL	386	533

TABLE 3.14

GHAZNI

Consumptive Use of Major Crops(mm)

Month	Wheat	Barley
Jan		
Feb		
Mar		
Apr	38	
May	137	49
June	156	149
July	84(½)	217
Aug		119
Sep		10(½)
Oct	22(½)	
Nov		
Dec		
TOTAL	437	544

TABLE 3.15

HERAT

Consumptive Use Major Crops (mm)

Month	Wheat	Cotton	Corn	Melons	Alfalfa	Vegetables (Spring)	Vegetables (Fall)	Orchards
Jan								
Feb								
Mar	88				56			31(½)
Apr	123				95	47		95
May	140	40		81	168	116		169
June	30(½)	93	115	150	239	174		221
July		197	227	203	281	158	110	281
Aug		234	253	87(½)	248		173	248
Sep		125	142		140		116	140
Oct	23(½)	30(½)	43(½)		70		56	92
Nov	49							
Dec								
TOTAL	453	719	780	521	1297	495	455	1267

TABLE 3.16

JABUL SERAJ

Consumptive Use Major Crops(mm)

Month	Wheat	Grapes	Ochards	Corn
Jan				
Feb				
Mar	74		26(½)	
Apr	113	42	83	
May	144	100	152	
June	72	158	219	101
July		178	237	192
Aug		154	228	215
Sep		85	140	132
Oct		49	88	
Nov	18(½)	17	37	
Dec				
TOTAL	421	783	1211	640

TABLE 3.17

JALALABAD

Consumptive Use Major Crops (mm)

Month	Wheat	Corn	Citrus	Cotton	Vegetables (Spring)	Vegetables (Fall)	Melons	Tomatoes (Spring)	Tomatoes (Fall)
Jan	63		29						
Feb	79		39		26		29	8(½)	
Mar	130		68		75		71	33	
Apr	124		99	36	114		113	69	
May	66		154	72	130		158	166	
June			200	153				290	33(½)
July		160	211	266				224	97
Aug		231	192	272					132
Sep		219	142	191		93			203
Oct		130	95	105		105			142
Nov	37		47	25(½)		58			54
Dec	53		31			29			
TOTAL	552	740	1307	1120	345	285	371	790	661

TABLE 3.18

KABUL

Consumptive Use of Major Crops (mm)

Month	Vegetables (Early)	Vegetables (Late)	Wheat	Tomatoes	Grapes	Corn
Jan						
Feb						
Mar			59			
Apr	35		99		21(½)	
May	84		113	51	78	
June	123	68	56	84	119	77
July	108	136		173	143	155
Aug		134		165	125	177
Sep		77		92	70	109
Oct			37		37	
Nov			38			
Dec						
TOTAL	350	415	402	565	593	518

TABLE 3.19

KALAT

Consumptive Use Major Crops (mm)

Month	Wheat	Melons	Barley
Jan			
Feb			
Mar	79		
Apr	123		47
May	145	71	143
June	71	137	240
July		175	157
Aug		132	40(½)
Sep			
Oct	13(½)		
Nov	39		
Dec			
TOTAL	470	515	627

TABLE 3.20

KANDAHAR

Consumptive Use   Major Crops(mm)

Month	Wheat	Grapes	Ochards	Vegetables (Spring)	Vegetables (Fall)	Early Tomatoes	Late Tomatoes
Jan	43						
Feb	62						
Mar	118	29	76	39		40	
Apr	133	65	124	98		80	
May	71	135	208	156		182	
June		186	253	143		233	55(½)
July		216	299		119	216	134
Aug		176	244		176		184
Sep		88	145		119		151
Oct		55	99		68		99
Nov	12(½)	22	49				28(½)
Dec	31						
TOTAL	470	972	1497	436	482	751	651

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TABLE 3.21

KUNDUZ

Consumptive Use Major Crops(mm)

Month	Wheat	Corn	Cotton	Melons	Vegetables (spring)	Vegetables (fall)
Jan						
Feb						
Mar	82					
Apr	141				45	
May	180		40	86	126	
June	40(½)		208	185	191	
July		134	222	199	186	116
Aug		201	240			179
Sep		167	137			127
Oct		93	60			61
Nov	39					
Dec						
TOTAL	482½	595	907	470	548	483

TABLE 3.22

LASHKAR GAH

[illegible] [illegible] Consumptive Use [illegible] Major Crops (mm)

Month	Wheat	Cotton	Corn	Melons	Beans	Grapes	Orchard
Jan	48						
Feb	71						23(½)
Mar	132					33	86
Apr	140	16		72		67	132
May	84	76		166		146	195
June		208		191		206	291
July		291	156		192	225	313
Aug		229	240		268	184	258
Sep		134	168		139	101	163
Oct		69	58			57	103
Nov	13					11(½)	49
Dec	34						
TOTAL	522	1023	622	429	599	1030	1613

TABLE 3.23

KANIKARA

Consumptive Use Major Crops(mm)

Month	heat	Corn	Cotton	Grapes
Jan				
Feb				
Mar	78			
Apr	119			44
May	152		33	100
June	33(½)	95	76	152
July		187	177	173
Aug		209	197	147
Sep		121	113	78
Oct	15(½)		49	39
Nov	44			10(½)
Dec	59			
TOTAL	500	612	645	743

TABLE 3.24

MAZARI SHARIF

Consumptive Use Major Crops (mm)

Month	Wheat	Cotton	Corn	Potatoes	Orchards	Grapes
Jan						
Feb						
Mar	21				32(½)	12(½)
Apr	146			3	108	55
May	192	43		18	194	132
June	46(½)	98	130	41	279	196
July		238	243	59	314	227
Aug		248	267	52(½)	262	187
Sep		140	148		154	94
Oct	33(½)	59			84	47
Nov	45				20(½)	9(½)
Dec						
TOTAL	483	826	788	173	1447	959

TABLE 3.25

MOKUR

Consumptive Use Major Crops (mm)

Month	Wheat	Corn	Melons
Jan			
Feb			
Mar	30(½)		
Apr	94		
May	138		
June	118	82	78
July	17(½)	161	137
Aug		176	131
Sep		100	76
Oct	60		
Nov			
Dec			
TOTAL	457	519	422

TABLE 3.26

QAASIS

Consumptive Use Major Crops(mm)

Month	Wheat	Corn	Cotton	Alfalfa
Jan				
Feb				
Mar	71			
Apr	105			78
May	128		28	126
June	56	77	62	169
July		147	140	193
Aug		181	159	168
Sep		69	95	106
Oct			46	112
Nov	26			20(½)
Dec	38			
TOTAL	424	494	530	972

TABLE 3.27

SHEBERGHAN

Consumptive Use Major Crops(mm)

Month	Wheat	Cotton	Barley	Corn
Jan				
Feb				
Mar	87			
Apr	134		63	
May	169	40	176	83
June	86	90	275	195
July		208	114	276
Aug		226		211
Sep		129		
Oct		60		
Nov	43			
Dec				
TOTAL	519	753	628	765

TABLE 3.28

ZARANJ

Consumptive Use Major Crops(mm)

Month	Wheat
Jan	47
Feb	74
Mar	146
Apr	162
May	89
June	
July	
Aug	
Sep	
Oct	
Nov	14(½)
Dec	37
TOTAL	569

4. KAREZ ASSESSMENT

4.1 Irrigation in Afghanistan

Over 50 percent of Afghanistan receives on average less than 300 mm of rain per annum (Figure 4.1). This is insufficient to support agriculture without irrigation. Out of the estimated seven percent of the land area that was cultivated before the war, over 52 percent was under irrigation (Table 4.1). Four main sources of water were used comprising:

(a)	Rivers and Streams	84.6%
(b)	Springs	7.9%
(c)	Karezes	7.0%
(d)	Persian Wheels (Arhat)	0.5%

Nearly 85 percent of the land under irrigation was supplied using surface water whether it be from direct diversion from the rivers and streams or from releases from storage reservoirs. Only seven percent of the irrigated area was supplied by karezes with an estimated 167,750 hectares being supplied in 1967-68 (Table 4.2). As few new karezes have been built in modern times, it is unlikely that this estimated area is far from the area actually irrigated by karezes before the war. If an error of ten percent is assumed in the compilation of these data, then it could be assumed that under 200,000 hectares of land was irrigated by karezes. The same source states the total number of karezes as 6,741 giving an average area per karez of about 25 ha (125 jeribs) (Table 1.3). The role of karez irrigation in Afghanistan must therefore been seen in this context.

4.2 Assistance Provided to Karez Cleaning

Many organisations became involved in karez cleaning, perhaps because it was a directly visible way of dispersing emergency relief money without having a defined and well thought out programme. Different approaches were adopted varying from the detailed and careful planning of the needs for repair, to the handing out of money without a clear indication of where the karezes were located, their names and the rehabilitation requirements. Overlap of work inevitably resulted and it is quite possible that the same karez received money under different names and different programmes. Records were poorly kept and the locations of the karezes cleaned were never clearly identified on a map except by a few organisations.

Planning of assistance for Karez cleaning needs to be brought on a sound engineering basis. To achieve this an understanding of the Karez system is first required.

4.3 Development of the Karez

With the spread of the Persian empire, the qanat system of irrigation was introduced into many countries that came under the Persian influence. This extended from North Africa where they are called Foggaras to Oman where they are called falajes and Afghanistan where they are called karezes. The principle adopted is the same and aims at tapping, by gravity, the underground aquifer by means of a series of underground tunnels or galleries that often extended for many

kilometres before surfacing to provide water for the cultivation of crops. In general, the classic system has three sections:

(a) The water collection section
(b) The water transporting section
(c) The distributing section

Sections (a) and (b) are mainly underground with section (c) found on the surface. The general principle of the karez is illustrated in Figure 4.2 and the main features on Figure 4.3.

The karez is usually found in arid regions where other visible forms of water for irrigation are not available. The systems often took many years to construct, but enabled the cultivation of relatively large areas of land that would otherwise have remained unused due to lack of sufficient water for even one crop. The simplest form is no more than a short diversion channel leading water to a small cultivable area. At this level, the karez and spring development are synonymous and often confused. The most complex form of the karez involves a fan of underground tunnels or galleries tapping the aquifer at different points and channelling the flow of water to the transporting section and onto the surface where it is distributed throughout the cultivated area. The original headwater of the karez, whether it provides the majority of water or not, is called the motherwell (Sarchah). As this is often never reopened, it is sometimes difficult to locate and can lead to confusion as to the length of the karez. In times of drought and where water has been a problem, karezes are often excavated beyond the original motherwell.

One characteristic of the karezes is the line of wells (Chahs) that served as access shafts during the original construction of the karez. They are now used as entry points to the underground channels for maintenance and withdrawing of rock debris, silt, stones and in some cases roots. These "corridors" between the surface and the karez allow surface forces to affect the karez as the tunnel itself also does. They are thus the weak point of the system and may cause the funnelling of rain water or wash flows into the karez resulting in siltation and perhaps well and tunnel collapse. Although the line of wells may seem straight upon the surface, underground they are often very sinuous, twisting and turning between the wells depending upon the conditions that the tunneller encountered. Similarly, during later repair and maintenance, it may have been necessary to re-route the channel after collapse.

The distance between the access shafts varies from about 10 to 35 linear metres, but is normally around 20 linear metres. The precise distance between each will depend upon the soil and rock encountered, but the sum of the depth of the shaft and half the distance between the shafts will never be greater than about 60 metres and normally in the order of 50 metres. Oxygen in the tunnels for the workers is the key element and it is for this reason that oil lamps and not modern torches are used underground.

In well maintained karezes, a minimum number of wells are kept open. It is necessary to keep a certain number exposed to ensure that they can be regularly checked by the karez kan and also to avoid excessive humidity build up where temperature gradients exist between the karez and the surface. Traditionally these wells were either closed near to the surface (1-2 metres below ground level) or someway between the tunnel invert and the surface. In both cases, large stones were laid

PREFACE

Since 1989 when the irrigation component of the FAO Programme for the Rehabilitation of Afghanistan Agriculture was initiated, much has been learnt on the way in which the rehabilitation works should be approached to ensure a long term impact. Although the FAO irrigation rehabilitation programme has concentrated on four Provinces to date[1], the systems established and the implementation approach has enabled FAO to respond rapidly to the requirements and demands presented with the expansion of the programme into new areas.

From the onset, the approach has been "Afghan led" and has thus essentially been a training and refresher programme for Afghan Engineers and technicians. All of the rehabilitation works have been implemented using NGOs, mostly local Afghan organizations, who are staffed by Engineers and technicians from the former Ministries in Kabul. The speed of implementation has been determined by the rate at which the NGOs could carry out the planned works to the established standards, given the prevailing infrastructural and security conditions.

This manual for the rehabilitation of irrigation systems in Afghanistan has drawn heavily upon the work of the FAO Irrigation Consultant[2] and the Afghan Irrigation Engineers working on the FAO Programme for the Rehabilitation of Afghanistan Agriculture. It sets out to utilize the experiences gained during the formulation and implementation of the FAO programme with the aim of making the approach and technical details widely available to all agencies contemplating work in this sector.

The first drafts of the manual were produced in 1992 by the Irrigation Consultant and were finalized in November 1993 following an Irrigation Design Workshop held in Peshawar from 1st to 3rd November 1993. During the discussions, comments and requirements of both the NGO and the International Donor community were examined and where possible and appropriate, these have been incorporated into the final version of the manual.

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1 Eastern Paktia, Kunar, Laghman and Nangarhar

2 Mr Ian McAllister Anderson.

across the well opening, being supported by dry stone masonry and covered with roots or other material to ensure that gravel and sand do not enter the shaft.

4.4 Types of Karezes found in Afghanistan

The types of karez that are found can be divided into three main groups:

(a) The long karez
(b) The short karez
(c) The tile karez (Chow or Jarr)

These are illustrated in Figure 4.4 and reflect the physical and hydrological conditions under which they were conceived. These include surface topography, the soil through which they pass and the permanence of the groundwater table that they tap. The length of the karez will indicate the general slope of the terrain in the area. The shorter it is, the steeper the land.

4.4.1 The Long Karez

This is the traditional karez and taps the more permanent water tables. Its length is usually between 1,000 and 4,000 metres, but karezes of up to about 13 km are found in Afghanistan. The motherwell is often located near to the hills and the aquifer and has been excavated from gravelly, conglomerate or hill wash material. Once the karez has travelled for some distance, it generally passes through more silty-clay soils or silty-sandy soils. Flow variation throughout the year are generally small and the lag time between rainfall and effect on the karez flows can be quite long.

4.4.2 The Short Karez

These are generally found in the higher elevations where agricultural land is more limited. They pass through much stonier material than the longer karezes and can be very tortuous and are more liable to collapse. Maintenance requirements are thus quite high and the karez tunnels are vulnerable to ground movements resulting from either natural causes (earthquakes) or unnatural causes (bombing).

Water table fluctuations are greater than in the longer karezes and lag times between fall and runoff are quite small. Karez flows are affected much more by the rain and snow melt and this means that the period for maintenance can be quite short and occurs during the winter months.

4.4.3 The Tile Karez (Chow or Jarr)

These karezes are located near to washes that may not have perennial surface but sub-surface flows. They are up to six metres in depth and comprise channels about one metre wide that have been excavated as an open channel and then closed using stone slabs supported on dry stone walls. Material has then been placed over the slabs or been washed in up to ground level. The height of these channels are about one metre. Tile karezes are the most costly and difficult to maintain as

they are subject to damage from the washes due to excessive entry of water or collapse of the walls. Access shafts are often not provided as they would permit the direct entry of the wash water. Thus to maintain the channels, temporary access shafts have either to be dug, or the whole channel re-excavated.

4.5 Categories of work involved in Karez cleaning, repair and improvement

The work that is carried out in the maintenance and repair of karezes can be split into several separate activities. When cost estimates are prepared, it is necessary to consider these different components as they affect the rate of output and the overall cost.

4.5.1 Cleaning and Repair

The general works that are undertaken in the cleaning and repair of a karez include:

- (a) Cleaning of silt and deposited material;
- (b) Opening and cleaning of wells;
- (c) Removal of collapsed material in the tunnel and repair of the tunnel;
- (d) Re-alignment of the tunnel where removal and repair of the existing tunnel is unfeasible;
- (e) Cleaning and repair of collapsed wells.

Once the area that has been blocked has been identified on site, the karez cleaners set about trying to remove the blockage and start some flow again. This is necessary so that they can gain access into the flooded part of the karez and identify the precise work that has to be carried out. The karez cleaning team comprises four people who are all skilled karez kans. They work with two underground and two on the surface, changing their places half way through the working day. Experience plays a very important role in the work as it is essential that the blockage is removed slowly to ensure against a sudden wave of water rushing down onto the workers and to limit the rate of drawdown in the saturated banks of the karez. Too rapid draw down will cause further collapses in the tunnel.

After the water flow has been resumed, the general cleaning process starts from upstream to down. This is because they workers feel that the material that is disturbed in the cleaning process will be carried down and cause further deposits downstream. Figure 4.5 illustrates the general cleaning process.

Well cleaning tends to be straight excavation work, although care has to be exercised to ensure that collapse of the sides is avoided. Where wells have been damaged, dry stone or pitched masonry are provided. New excavation around blocked areas is a more skillful process and requires the experience of the karez kan to decide when alternative alignments should be adopted.

4.5.2 Improvements

In addition to the works required to get the karez operational again, there are certain improvements that are carried out to reduce future damage and maintenance requirements. These include:

(a) Capping of wells to prevent runoff and rain damage using masonry dome type structures fitted with metal or stone covers;

(b) Protection of wells against flood entry and damage using similar structures to (a) above;

(c) Improvements to the open channel sections by providing stone pitching, masonry lining and structures to take the channels over washes.

There is insufficient documented evidence to indicate that improvements are also made to reduce losses within the irrigated area. This is probably one of the most important areas for future consideration.

4.6. Breakdown of work

In order to assess the precise requirements of the cleaning and repair work, the rate of output for each of the activities involved in karez cleaning and indicated above have been estimated below.

4.6.1 Equipment

The equipment that are required per team for karez cleaning and excavation are listed in Table 4.4 together with the cost. Although there are some variations in the types of hand tools and quantities, it is realistic to consider that for the effective operation of the team, the amounts shown should be provided. In some cases wheel barrows are not required. However, to ensure that material is not deposited too near the well, barrows should be provided.

It can be seen therefore that an allowance for equipment of Rs 4,000 per karez team would be reasonable (at 1991 prices).

4.6.2 Output for Cleaning works

The amount of material that can be cleaned from a canal by a team is governed more by the volume of material that a Salwarga can hold, its weight and the turn around cycle for filling and emptying it. The capacity of the Salwarga is estimated at 0.0285 cubic metres of wet silt with a weight of around 60 kg (see Figure 4.5). Considering an eight hour working day and an average cycle time of eight minutes (to include stoppage and turn around time and varying distance from the well), the output of one four man team would be 60 cycles per day or 1.70 cubic metres per day. Although only one man is actually digging material at a time, he only spends two hours a day in this role. The output per man per two hour session of 0.43 m^3 thus seems to be reasonable.

Depending upon the depth of material and the width of the channel, a rate of cleaning of between 4 and 28 linear metres per day per team can derive. However for planning purposes an average rate of 11 linear metres per day per team seems to be reasonable for those karezes where routine maintenance has been neglected.

4.6.3 Output for Cleaning and Repair of Collapsed Wells

Well cleaning work also requires experienced teams to ensure that collapse of the walls does not occur during excavation. However because of the shorter distance that the material has to be raised and hauled, and the restricted working area, a three man team is usually used. For this team, a cycle time for the Salwarga of five minutes can be assumed. This gives an output rate of about 2.75 cubic metres per day per team or a depth of cleaning of between 3.0 and 3.5 metres per team per day.

4.6.4 Output for Opening and Cleaning of Wells

Wells are either capped within two metres of the surface or near to the tunnel. The experienced karez kan from the karez in question will normally know approximately where the well has been capped and the reasons for it. This will also reflect the history of the well and whether it has been capped to prevent further collapse and blocking of the karez, or whether the capping has just been planned as part of the properly managed karez. For the opening of a karez capped near the surface, a two man team is required. Normally this would be done without the use of a Salwarga and thus the output is governed by the output of the men and not the capacity of the Salwarga. Considering the need to remove the material away from the well and the maximum depth of dig of 2 metres, the output per two man team would be about 2.75 cubic metres per day. For wells that are capped near to the tunnel, the rate for well cleaning would apply.

4.6.5 Output for Removal of collapsed material in the tunnel

Excavation of the collapsed material from within the tunnel takes more time and requires to be carried out carefully. In general however the material is looser than unexcavated material. The same approach to that adopted in 4.6.2 above is assumed but with an average cycle time of 10 minutes, or 6 per hour. This gives an output of 1.37 cubic metres per day per team of four men.

4.6.6 Re-alignment of the tunnel where removal of collapsed material is unfeasible

The need for re-alignment of karez tunnels will occur on the longer karezes in silty-clay material where the water table has been allowed to become too high. Thus although the wells may be deeper than in the shorter karezes, the work is easier. A common approach to both situations has thus been taken without differentiation between soil types. The approach adopted is thus the same as 4.6.5 above except that a cycle time of 12 minutes is assumed. This gives the average output per team per day of 1.14 cubic metres of material.

4.7 Command areas and unit flows

Few data on crops grown and cropping patterns in the areas irrigated by karezes have been collected. There has thus been no measure of the estimated consumptive use of the crops and the

average crop water requirements. Cropping intensities[1] will vary from around 120 percent up to about 160 percent and will reflect the variation in the flow of water and the altitude of the irrigated area. Flows of karezes should be directly related to irrigated areas as this will give an indication of the water management and cultivation practices and the constraints operating. Where imbalances occur further investigation is required as the areas or flows may be wrongly estimated, there are other constraints such as very poor water distribution efficiency or too few farmers.

Monthly water supply should be equated to demand. In the absence of any pattern of supply and demand, estimates of peak demand for average cropping patterns can be made. If it is assumed that the peak 24 hour farm gate requirement for a mixed cropping pattern of wheat, maize, vegetables and fruit trees is 0.9 l/s/ha at the farmgate, and that the losses in the open channel distribution system are 20 percent, then the requirement at the point of emergence of the karez will be about 1.125 l/s/ha. Measurements on karez systems in other countries has shown that 20-30 percent of the karez flow will be lost in the transporting section. This will therefore give an approximate continuous peak flow requirement of 1.60 l/s/ha at the source. When this is translated into average flows and allowances for phased plantings and net to gross hectares, a 24 hour flow of about 0.7 l/s/gross ha is required at the outlet of the karez for optimum production. Any flow around 0.6 l/s/gross ha should therefore be sufficient to meet irrigation demands.

4.8 Norms

In Table 4.5, an attempt has been made to examine the norms that are adopted by the NGOs. The agricultural sub-committee of ACBAR has published norms for different karez work, but this tends to have been superseded by the experience of the NGOs themselves. Most NGOs now agree that a karez cleaning team should comprise four experienced karez kans and that an average output would be 1.7 cubic metres per day. Variations occur in the assumption of the depth of silt and this is reflected in the estimated output per metre run per day.

Excavation work for wells seems to vary more, although a general figure of about 3.0 cubic metre per team per day seems to derive. The composition of the team varies from three to four labourers of which one to two are skilled.

Tunnel repair works and new excavation in the tunnel vary from 0.90 up to 1.90 cubic metres per team per day. Few NGOs actually record the types of soil and the amounts of such works that are required, and thus such calculations appear to be rather academic.

Quantities of equipment used by each team seem to more or less agree, but total numbers depend upon the rate of implementation and the numbers of teams working simultaneously. The average tool cost per metre run of output varies for selected projects from between 1.2 and 2.5 Rs/m.

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1. This reflects the utilization of the land. 100 percent indicates full cropping of the land for one crop per year. 200 percent indicates full cropping of the land for two crops per year.

4.9 Recommendations on Approach to Karez Cleaning

As karezes represent only a small proportion of the systems that supply irrigation water, their importance must not be over emphasised. Whereas there are obviously still karezes that require cleaning, they must not be seen in isolation. The merits of supporting them must be seen in the overall context of improving the output of the existing commanded and formerly cultivated lands. Sufficient data must therefore be presented to justify this.

Reliance must be put on the NGOs as implementing partners in the foreseeable future. They therefore must be encouraged to provide sufficient and reliable data in suitable formats. Guidelines should be produced to ensure that what are collected cover all of the basic data requirements requested in Table 4.8. It is proposed that the project cycle is split into various phases and that at the end of each of these phases, data are provided in the required format and the meeting of these requirements is used as certification for payment. This is set out in Table 4.6. The division between Phases 1 & 2 will depend upon whether studies have already been carried out and also on whether the proposals have been submitted. Various aspects that need particular attention during the course of project preparation and implementation are discussed below.

4.10 Budgeting

The information that should be provided in the build up of the project costs should cover at least the following:

- (i) output per manday per task,
- (ii) number of men in team,
- (iii) equipment required per team,
- (iv) amount of cleaning needed in each section,
- (v) supervisory staff on each work site,
- (vi) supervisory staff in each headquarters and number of sites under their jurisdiction,
- (vii) transport and number of sites to be visited and distance between them,
- (viii) unit rates per staff and materials,
- (ix) payment schedule.

Estimation of the amount of cleaning required has been discussed earlier. Determination of precise requirements will be made from the field data collected using the proposed standard forms (1 and 2). In Table 4.9 a worked example is presented in order to clarify this process.

Table 4.1 Irrigated and Non-Irrigated Area by Provinces in 1967-68[1]

	Province	Farm Population (000 Persons)	Number of land and livestock owners (000 Persons)	Cultivated Area (000 hectares) Irrigated	Non-Irrigated	Total
1.	Urozgan	369.92	94.95	126.59	4.39	130.98
2.	Badghis	295.26	38.31	33.30	120.80	154.10
3.	Bamian	285.04	27.10	23.16	6.76	29.92
4.	Badakhshan	398.72	52.08	61.76	1201.16	181.92
5.	Baghlan	466.98	42.54	80.18	149.65	229.83
6.	Balkh	270.22	49.85	224.50	88.69	313.19
7.	Parwan	493.72	63.70	35.14	13.59	48.73
8.	Paktia	704.69	79.40	56.34	31.37	87.71
9.	Takhar	332.33	40.30	61.85	298.30	360.15
10.	Jauzjan	290.56	41.85	184.60	99.74	284.34
11.	Zabul	267.35	19.70	62.54	18.36	80.90
12.	Samangan	222.15	47.01	44.34	145.92	190.26
13.	Ghazni	740.21	65.83	117.48	51.89	169.37
14.	Ghor	217.28	39.03	72.85	98.37	171.22
15.	Faryab	415.45	46.94	121.61	192.85	314.46
16.	Farah	290.25	23.93	125.73	22.60	148.33
17.	Kabul	639.80	45.43	57.60	10.06	67.66
18.	Kapisa	460.81	49.78	39.94	0.50	40.44
19.	Kunduz	354.43	52.05	209.59	85.71	295.30
20.	Kandahar	580.00	48.43	117.92	39.55	157.47
21.	Kunar	261.67	30.70	23.31	3.11	26.42
22.	Laghman	161.91	30.05	23.58	1.50	25.08
23.	Logar	237.39	34.84	26.65	17.33	43.98
24.	Nangarhar	640.90	77.76	42.35	18.13	60.48
25.	Neemroz	119.10	18.58	60.30	185.50	245.80
26.	Wardak	382.74	29.43	25.60	1.81	27.41
27.	Herat	685.00	90.15	163.69	337.00	500.69
28.	Helmand	255.99	27.45	162.72	0.22	162.94
	Total	10,839.87	1,307.17	2,385.22	2,163.86	4,549.08
	Nomads	2,500.00	360.00	-	-	-
	Grand Total	13,339.87	1,667.17	2,385.22	2,163.86	4,549.08

1. Statistical Yearbook, Government of Afghanistan, 1980

Table 4.2 Irrigated Area Source and Province in 1967-68[1]

	Province	Area cultivated by different sources of irrigation				
		Streams and Canals	Springs	Karezes	Persian wells (Arhat)	Total Irrigated Land
1.	Urozgan	52.67	56.28	17.55	0.08	126.58
2.	Badghis	20.25	8.66	4.39	-	33.30
3.	Bamian	17.26	5.35	-	0.54	23.15
4.	Badakhshan	57.83	3.84	-	0.09	61.76
5.	Baghlan	80.02	0.16	-	-	80.18
6.	Balkh	224.25	0.20	-	0.05	224.50
7.	Parwan and Kapisa	62.77	10.34	1.98	0.05	75.14
8.	Paktia	45.74	4.68	5.86	0.07	56.35
9.	Takhar	53.35	8.15	-	0.36	61.86
10.	Jauzjan	182.42	2.06	0.02	0.10	184.60
11.	Zabul	37.67	11.99	12.78	0.10	62.54
12.	Samangan	37.61	5.84	0.41	0.47	44.33
13.	Ghazni	74.32	14.53	23.96	4.68	117.49
14.	Ghor	55.92	15.99	0.71	0.24	72.86
15.	Faryab	116.70	4.25	0.38	0.27	121.60
16.	Farah	88.84	7.35	28.48	1.06	125.73
17.	Kabul	38.88	3.30	14.76	0.66	57.60
18.	Kunduz	209.05	-	-	0.54	209.59
19.	Kandahar	96.05	5.31	15.86	0.70	117.92
20.	Kunar	22.59	0.72	-	0.01	23.32
21.	Laghman	23.52	0.06	-	-	23.58
22.	Logar	21.86	0.17	4.38	0.24	26.65
23.	Nangarhar	28.52	4.36	9.45	0.01	42.34
24.	Neemroz	59.74	-	0.32	0.24	60.30
25.	Wardak	14.93	8.69	1.98	-	25.60
26.	Herat	159.85	0.83	1.65	1.37	163.70
27.	Helmand	135.44	4.32	22.83	0.13	162.72
	Total	2,018.05	187.43	167.75	12.06	2,385.29
	%	84.6	7.9	7.0	0.5	100.0

1. Statistical Yearbook, Government of Afghanistan, 1980

Table 4.3 Number of Irrigation Sources by Province in 1967-68[1]

	Province	Streams and Canals	Springs	Karezes	Persian wells (Arhat)
1.	Urozgan	363	429	84	210
2.	Badghis	120	50	30	-
3.	Bamian	179	137	-	300
4.	Badakhshan	212	82	-	54
5.	Baghlan	109	63	-	-
6.	Balkh	250	92	3	82
7.	Parwan	120	93	34	-
8.	Paktia	625	392	528	800
9.	Takhar	316	288	-	509
10.	Jauzjan	382	87	2	443
11.	Zabul	199	756	743	148
12.	Samangan	20	73	7	271
13.	Ghazni	818	604	1,516	636
14.	Ghor	804	570	4	263
15.	Faryab	157	79	960	867
16.	Farah	312	94	352	2,324
17.	Kabul	177	81	321	436
18.	Kapisa	285	72	49	176
19.	Kunduz	88	-	-	55
20.	Kandahar	279	258	631	252
21.	Kunar	223	67	-	13
22.	Laghman	45	3	-	-
23.	Logar	154	169	124	91
24.	Nangarhar	274	210	495	15
25.	Neemroz	193	2	18	140
26.	Wardak	589	519	336	-
27.	Herat	302	153	228	450
28.	Helmand	227	135	276	60
	Total	7,822	5,558	6,741	8,595

1. Statistical Yearbook, Government of Afghanistan, 1980

Table 4.4 Equipment Required by Karez Cleaning Team

	Item of Equipment	Unit	Quantity	Cost (Rs)
1.	Wheel and pulley (local wood manufacture)	No.	1	750.00
2.	Rope	m	60	360.00
3.	Pick	No.	2	180.00
4.	Shovel	No.	3	210.00
5.	Sledge Hammer	No.	1	200.00
6.	Chisel	No.	2	120.00
7.	Wheelbarrow	No.	1	650.00
8.	Salwarga (leather bucket)	No.	2	700.00
9.	Oil for Lamp	kg	10	700.00
	Total Cost			3,870.00

Note: 1991 prices

1. INITIAL ASSESSMENT AND PRIORITIZATION FOR REHABILITATION

1.1. Introduction

During the implementation of the FAO programme for the rehabilitation of Afghanistan irrigation systems, it was recognized that the major part of the problems stem from the failure to maintain the systems adequately during the war years. Social organizations established for many generations broke down and thus the first and most important part of the rehabilitation process has been to encourage the farmers to come back to their land and start to re-form the village organizations and structures that existed before the start of hostilities.

A key to the successful approach to the rehabilitation of the irrigation systems has been to encourage people to return to their lands. This has to be a rapid and continuous process to ensure that the initial momentum is not lost and that as more farmers return, all are seen to benefit and be involved in the rehabilitation process. It is difficult to determine where rehabilitation stops and development starts, but the approach has been to return the irrigation systems at least to the level they were at before hostilities started, but also to ensure that any interventions are sustainable and in the interest of the long term improvements of the traditional irrigation systems.

The steps that have been followed and derived since the start of the programme are discussed below so that all organizations involved in the rehabilitation process can utilize the experiences gained and approaches adopted to specific problems identified during implementation of the works. It is important to recognize that the rehabilitation process is not only one of physical repair of the irrigation systems, but also a training and refresher programme for Afghan Engineers and Technicians.

Although many of the details contained in this manual relate both to formal and informal irrigation systems, the manual has been written for the informal traditional irrigation schemes within Afghanistan.

1.2. Approach

Rehabilitation has been divided into five stages extending from the initial assessment of the needs of an area to the completion of the major structural work considered necessary to bring the irrigation systems to at least the condition that they were in before the start of hostilities in 1979. These comprise:

Stage I 1. Field Reconnaissance Surveys

Stage II :
1. Immediate initial cleaning,
2. Canal plan and inventory surveys,
3. Canal topographical surveys,

Table 4.5 Assumptions made by Organisations in Assessment of Karez Cleaning

ITEM	DESCRIPTION	Unit	ACBAR	UNDP	WFP	RAFA	IRC	SCF(USA)	ESAR	SCA	FRF
	Date				1990	29/5/90		1/7/90	15/6/91		1/1/90
	Area				Paktika	Paktika		Kandahar	Wardak	Sayedabad	Farah
1	KAREZ DETAILS										
1.1	Average Length	km	1.0-3.0	1.0-3.0	1.200	0.1-6.0	)	1.300	.722	.515	6.000
1.2	Average gross area served - now	Hectare		-	4.0		)		12	14.0	40.0
1.3	Average gross area served - after	Hectare		-			) measured		94	44.5	80.0
1.4	Percentage of gross area served now	%		-			) on site	12.0	13	31	50.0
1.5	Average Number of wells	No.		-		39.9	) for		35.4	23.1	
1.6	Average Distance between wells	m		15-20	30.0	36.3	) each		20.4	22.3	
1.7	Average Depth of wells	m		-	3.5	25-35	) Karez			15.2	
1.8	Average Well diameter	m		1.0x0.80	1.0		)				
1.9	No of wells to be repaired	No.		-		18.5	)		14.0		
1.10	No of wells to be repaired	%		-		46.4	)		39.7		
1.11	Average Width of Karez	m	0.6-0.8	0.6-0.8	.6	.9	0.6-0.8			0.65-0.75	0.7-0.8
1.12	Average Height of Karez	m		1.2	1.2	1.2	1.2			1.25	
1.13	Depth of silt	m	0.1-0.5	0.1-0.5	.25		.40		.30	0.25-0.35	.30
2	KAREZ TEAM FOR CLEANING										
2.1	Team	Number	4.0	4.0	4.0	4.0	4.0		4.0	4-5	19.0
2.2	- Skilled	Number	1.0	2.0	4.0	4.0	4.0	1.0	2.0	4-5	1.0
2.3	- Unskilled	Number	3.0	2.0	.0	.0	.0	3.0	2.0	.0	18.0
2.4	Salary Rate - Skilled	Rs/day		80.0	80+7kg	80+7kg	115.0	100+7kg	70-100	120-160	60.0
2.5	- Unskilled	Rs/day		40.0	30+7kg	80+7kg	40.0	50+7kg	50-80	-	30+7kg
2.6	- Team	Rs/day		240.0	440.0	320+7kg	460.0	250+28kg	240.0	480-640	
2.7	Output - skilled labour	m3/day		-			.75	2.5		-	
2.8	- Unskilled labour	m3/day		-			.75	2.5		-	
2.9	- Team	m3/day	2.6	2.6	1.7	1.7	3.00	2.5		1.7	
2.10	- Team	l.m./day	43.3-6.5	10.0	10.0	1.7	10.0	25.0	10.0	8-10	30.4
2.11	Work Days per month	days		25.0	26.0	25.0	26.0	26.0	26.0	26.0	30.0
3	KAREZ TEAM FOR NEW WORK/REPAIR										
3.1	Team for new excavation	Number	4.0	4.0			2.0			4-5	
3.2	- Skilled	Number	1.0	2.0			1.0			4-5	
3.3	- Unskilled	Number	3.0	2.0			1.0			.0	
3.4	Salary Rate - Skilled	Rs/day		100.0	80+7kg					120-160	
3.5	- Unskilled	Rs/day		50.0	30+7kg					-	
3.6	- Team	Rs/day		300.0						480-640	
3.7	Output - skilled labour	m3/day	.35	.35			.6			-	
3.8	- Unskilled labour	m3/day	.35	.35			.6			-	
3.9	- Team	m3/day	1.4	1.4			1.2			1.7	
3.10	- Team	l.m./day	2.0	2.0						8-10	
3.11	Team for stonework	Number	4.0	4.0	3.0					4.0	
3.12	- Skilled	Number	1.0	1.0	1.0					1.0	
3.13	- Unskilled	Number	3.0	3.0	2.0					3.0	
3.14	Salary Rate - Skilled	Rs/day		100.0	80+7kg		70.0			160.0	
3.15	- Unskilled	Rs/day		50.0	30+7kg					60-68	
3.16	- Team	Rs/day		300.0	230.0					350.0	
3.17	Output - team	m3/day	6.00		4.0			2.6		2.0	

	4.	Canal design
Stage III:	1.	Final canal cleaning to FSL (Full Supply Level),
	2.	Detailed topographical survey of sites for structure repair/ improvement under stage IV,
	3.	Structure Design and construction planning (Phase A).
Stage IV:	1.	Implementation of Phase A of the structural work,
	2.	Detailed topographical survey of sites for structure repair/ improvement under stage V,
	3.	Structure Design and construction planning (Phase B).
	4.	Monitoring and follow-up of Phase A works.
Stage V:	1.	Implementation of Phase B of the structural work.
	2.	Monitoring and follow-up of Phase B works.

The main details of each of these stages together with the sequence which should be followed is illustrated in Table 1.1 at the end of this chapter.

Work should be carefully planned to ensure that the canals systems have adequate capacity to meet the peak demands of the first crop season to follow the return of the refugees. Stage II should commence as soon as possible after the initial reconnaissance mission has been completed, with funds being made immediately available for the canal cleaning and additional planning exercises and agreements being drawn up with the implementing organizations and the benefitting communities. In the preparation of these agreements, the following should be considered:

(a) The provision of suitably experienced technical staff by the implementing organization for the surveys of the primary canal systems providing water to the main irrigated lands within the selected command areas.

(b) The provision of skilled and unskilled labour as required for the immediate cleaning of major canals in each command area based on data provided by the donor agency.

(c) The determination of a priority plan for assistance based on the canals surveyed and the extent of the command area of each.

(d) The construction of the works according to the designs, specifications and work plans prepared by the donor agency.

Table 4.3 (Continued) - Assumptions made by orga...

ITEM	DESCRIPTION	Unit	Date Area	ACBAR	UNDP	WFP 1990 Paktika	RAFA 29/5/90 Paktika	IRC	SCF(USA) 1/7/90 Kandahar	ESAR 15/6/91 Wardak	SCA Sayedabad	FRF 1/1/90 Farah
						ORGANISATION						
4	SALARIES											
4.1	Project Engineer	Rs/month			6000.0		7000.0		6500.0		6000.0	6000.0
4.2	Site Engineer	Rs/month			5000.0		5000.0		5500.0		5000.0	5000.0
4.3	Site supervisor	Rs/month			3000.0		3000.0		4500.0	6000.0	-	2000.0
4.4	Site Monitor	Rs/month			3000.0				5500.0	5000.0	-	
4.5	Foreman	Rs/day			100.0					153.8	-	
4.6	Mason	Rs/day			80.0	80+7kg	120.0		130.0		160.0	
4.7	Skilled Karez Khan	Rs/day			80.0	80+7kg			80.0		120-160	60.0
4.8	Unskilled labour	Rs/day			40.0	30+7kg			80.0		60-68	90.0
4.9	Storeman	Rs/day			40.0				173.1		-	
4.10	Watchman	Rs/day			40.0		60.0		115.4	69.2	-	
4.11	Field Allowance	Rs/day			100-200		80.0		115.4	100.0	+60%	100.0
4.12	Agency Admin -	Rs/month					20000.0		13000.0	30000.0	-	10800.0
4.13	Agency Admin -	% of cost			<10%		2.0		2.0	10.0	-	3.0
5	UNIT RATES											
5.1	Materials - Stone	Rs/m3			80.0	67.0		80.0			200-240	
5.2	- Sand	Rs/m3			80.0	50.0	100.0	120.0			120-160	
5.3	- Cement	/50kg bag			100.0	120.0	120.0	100+Tran	100.0		100+trans	
5.4	- Brick	Rs/m3			-			-		-		
5.5	Equipment per Team - Winch/pulley	No/team			1.0	1.0	1.0	)	1.0	1.0	1.0	1.0
	- Winch/pulley	Rs				300.0	1100.0	)	500.0	600.0	800.0	166.0
5.6	- Rope	m/team			60.0	100.0	32.0	)	60.0	200.0	50.0	20.0
	- Rope	Rs				500.0	320.0	) Lump	400.0	2000.0	1000.0	220.0
5.7	- Cable	m			-	.0	.0	) sum to	60.0	.0	.0	.0
	- Cable	Rs				.0	.0	) Shura	900.0	.0	.0	.0
5.8	- Pick	No.			3.0	2.0	1.0	) as per	1.0	2.0	2.0	2.0
	- Pick	Rs			180.0	120.0	60.0	) agreement	50.0	160.0	200.0	67.0
5.9	- Shovel	No.			4.0	2.0	1.0	)	1.0	2.0	3.0	4.0
	- Shovel	Rs			200.0	200.0	50.0	)	60.0	140.0	360.0	340.0
5.10	- Sledge	No.			1.0	.0	.0	)	1.0	.0	1.0	1.0
	- Sledge	Rs			50.0	.0	.0	)	250.0	.0	320.0	167.0
5.11	- Chisel	No.			1.0	.0	.0	)	1.0	.0	2.0	3.0
	- Chisel	Rs			30.0	.0	.0	)	20.0	.0	120.0	16.0
5.12	- Wheelbarrow	No.			1.0	.0	.0	)	1.0	.0	1.0	
	- Wheelbarrow	Rs				.0	.0	)	650.0	.0	1400.0	
5.13	- Bucket (leather)	No.			2.0	2.0	1.0	)	1.0	2.0	2.0	
	- Bucket	Rs			800.0	200.0	210.0	)	50.0	400.0	666.7	
5.14	- Bucket (Metal)	No.			.0	.0	.0	)	.0	.0	.0	
	- Bucket	Rs			.0	.0	.0	)	.0	.0	.0	
5.15	- Oil Lamp	No.			15 kg		.0	)	.0	.0	10 kg	
	- Oil Lamp	Rs			600.0	100.0	.0	)	.0	250.0	800.0	
5.16	- Crow bar	No.			.0	.0	.0	)	1.0	.0	.0	
	- Crow bar	Rs			.0	.0	.0	)	120.0	.0	.0	
5.17	Average tool cost - per team	Rs/team			1860.0	1420.0	1740.0		3000.0	3550.0	5666.7	976.0
5.[illegible]	- per output	Rs/m			.9	1.2	1.2		2.3	2.5	5.5	.2

Table 4.5 (continued) Assumptions made by Organisations in Assessment of Karez Cleaning

ITEM	DESCRIPTION	Unit	Date / Area	ACBAR	UNDP	WFP 1990 Paktika	RAFA 29/5/90 Paktika	IRC	SCF(USA) 1/7/90 Kandahar	ESAR 15/6/91 Wardak	SCA Sayedabad	FRF 1/1/90 Farah
				ORGANISATION								
6	IMPLEMENTATION											
6.1	Hire labour - NGO				) no	Y	Y	-		-	-	Y
	- Karez Owner/Kan				) preference	-	-	-		Y	Y	-
	- Shura				)		-	-	Y	-	-	-
6.2	Pay labour - NGO				)		Y	Y	-	Y	Y	Y
	- Karez Owner/Kan				) up to		-	-	-	-	-	-
	- Shura				) NGO		-	-	Y	-	-	-
6.3	Agreement - Shura				)		Y	Y	Y	Y	Y	-
	- Karez Owner/Kan				)		-	-	-	Y	Y	-
	- Beneficiaries				)		-	-	-	-	-	-
	- Other				)		-	-	-		-	-
6.4	Duration	km/month/team					.274			.241	.200	.563
6.5	Project Supervision Team											
	- Project Engineer	No.			.05		.04	.04				.10
	- Site Engineer	No.			.05	.08	.14	.08				.10
	- Site supervisor	No.			1.00	.25	.29	.08		.05		.20
	- Site Monitor	No.			.05	.00		.04		.05		
	- Foreman	No.			.00	.17	)			.05		1.00
	- Storeman	No.			.14	.00	) Shura					
	- Watchman	No.			.29	.17	.04)			.09		
	- Team Cost	per month										
	- Team Cost	per km										

Note: 1. Based on data from specific projects. Blanks indicate data not readily available.
2. Data based on mid 1991 prices

Table 4.6 Recommended Steps for Funding of Karez Cleaning Works

Phase	Details	Funding	Action
1.	General data collection on areas in which assistance is proposed for project document.	General survey either carried out by UNDP or by NGO from its own funding, own sources and minimum data on Form 1 provided.	Proceed to Phase 2 when UNDP accepts Project Document.
2.	Detailed survey of all of the karezes existing in the identified area and the identification of the requirements of each and an initial ranking for assistance. Screening of these karezes for selection for the implementation stage considering the technical requirements and priorities as well as the village and Shura preference.	Prepayment from UNDP of 15 percent of the proposed contract value before the start of the survey. Data requested in Form 2 should be collected and presented in UNDP format for karez project documents. Detailed estimates should be provided of the breakdown in costs and implementation arrangements for the selected karezes.	Proceed to Phase 3 when UNDP accepts data collected on Form 2 and the presentation of the data, in the UNDP karez cleaning format.
3.	Implementation of the first part of the cleaning work according to the work plan for the karezes presented at the end of Phase 2.	Mobilisation payment of 25 percent of the total contract price. On completion of 50 percent of the proposed work, a further 25 percent of the contract price will be paid to the NGO.	Payment will only be made if adequate reporting is made by NGO according to UNDP karez format.
	For those larger projects, detailed surveys of the remaining karezes existing in the identified area and the identification of the requirements of each and an initial ranking for assistance. Screening of these karezes for selection for the implementation during the next stage considering the technical requirements and priorities as well as the village and Shura preferences.	A further 25 percent of the contract value will be paid on completion of all of the cleaning and repair work.	

Phase	Details	Funding	Action
4.	On completion of all cleaning work, preparation of final report giving all results with technical details as specified by UNDP in an acceptable format.	Final payment of the remaining 10 percent released after submission of the final report by the NGO and the checking in the field of selected projects by the UNDP monitoring and evaluation engineer.	Recommended for further work when project passed by UNDP engineers and final report accepted by UNDP.

Table 4.7 Form I - Minimum Data Collection
for Project Document (Phase I)

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1. Scale location map of area to be assisted giving names of villages and approximate location of karezes and main features/problems of the area.

2. Administration arrangements for area
   - 2.1 Name of area/sub-district/district
   - 2.2 Centre
   - 2.3 Shura(s)
   - 2.4 Commander(s)

3. Security/access problems

4. Attitude of local people

5. Population of area
   - 5.1 Before war
   - 5.2 Present

6. Previous assistance provided to any of the karezes in the area either by UNDP or other organisations.

7. Reasons for Project
   - 7.1 Type of damage
   - 7.2 Cause of damage
     - 7.2.1 War/bombing
     - 7.2.2 Lack of maintenance
     - 7.2.3 Flood/rain
     - 7.2.4 Other
   - 7.3 Areas with mines

8. Labour
   - 8.1 Availability
     - 8.1.1 Source of skilled karez labour
     - 8.1.2 Source of unskilled labour
   - 8.2 Current wage rates in the area
     - 8.2.1 Skilled karez labour
     - 8.2.2 Unskilled labour

Table 4.7 (continued) Form 1 - Minimum Data Collection
for Project Document (Phase I)

9. Information on karezes known to exist in the area and to be included in detailed survey:

9.1 name
9.2 Location of karez (map)
9.3 Name of village(s) and their location
9.4 Ownership (number and names of kans or villages)
9.5 Terrain in which karez is located and runs
9.6 Type of karez
  9.6.1 Tunnel karez
  9.6.2 Tile karez (Chow or Jarr)
9.7 Length from Owkura (0+000) to mother well
9.8 Wells
  9.8.1 Total number
  9.8.2 Distance between each well
  9.8.3 Number collapsed or closed
9.9 Night storage reservoir
9.10 Area to be served
  9.10.1 Plan of area with approximate shape
  9.10.2 Gross commanded area (hectares)
  9.10.3 Presently irrigated area (net hectares)
9.11 Length of canal fro Owkura to irrigated agricultural land
9.12 Problems experienced in open conveyance section
  9.12.1 Number of washes to be crossed
  9.12.2 Damage from rivers or washes
  9.12.3 Other problems
9.13 Agriculture
  9.13.1 Present situation
  (a) Crops grown
    (i) Planting date
    (ii) Harvesting date
  9.13.2 Situation before the war
  (a) Crops grown
    (i) Planting date
    (ii) Harvesting date
9.14 Beneficiaries
  9.14.1 Number
  9.14.2 Heads of family
  9.14.3 Number per family
  9.14.4 Average Land Holdings
9.15 Method of assessment and costing of karez cleaning requirements

Table 4.8 Form 2 - Detailed Data Collection for Project Implementation (Phase II)

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1. Location of karez (map)
2. name of village(s) and their location
3. Ownership of karez (number and names of kans or villages
4. Security/access problems
5. Terrain in which karez is located and runs
   - 5.1 From foothills to Flat Plain
   - 5.2 In foothills
   - 5.3 Outwash fan/relatively steep terrain
   - 5.4 Within or close to river/wash
6. Type of karez
   - 6.1 Tunnel karez
   - 6.2 Tile karez (Chow or Jarr)
7. Karez main details
   - 7.1 Location sketch map of layout showing approximate alignment, wells and main features/problems of the area
   - 7.2 Length from Owkura (0+000) to mother well
   - 7.3 Wells
     - 7.3.1 Number
     - 7.3.2 Distance between each well
     - 7.3.3 Condition of each well
     - (a) Open
     - (b) Closed
     - (c) Capped
       - (i) Surface
       - (ii) Near tunnel
     - (d) Collapsed
     - 7.3.4 Diameter of each well
     - 7.3.5 Depth of each well from typical ground level
     - 7.3.6 Water situation in each well
     - (a) Dry
     - (b) Water
       - (i) Depth
       - (ii) Moving or stagnant

Table 4.8 (continued) Form 2 - Detailed Data Collection for Project Implementation (Phase II)

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8. Night storage tank?
    - 8.1 Sketch of layout
    - 8.2 Size (dimensions)
    - 8.3 Shape of inlet channel (dimensions and sketch)
    - 8.4 Depth of reservoir
        - 8.4.1 Difference between inlet/outlet levels
        - 8.4.2 Depth at centre
9. Drinking area (Owkura) protected?
10. Area to be served
    - 10.1 Plan of area with approximate shape, length and width
    - 10.2 Gross commanded area (hectares)
        - 10.2.1 Total area
        - 10.2.2 Always cultivated
        - 10.2.3 Sometimes cultivated
        - 10.2.4 Presently cultivated
    - 10.3 Irrigated area (net hectares)
11. Flow
    - 11.1 Flow on date of survey (measured by floating sticks)
    - 11.2 Month with maximum flow
    - 11.3 Month with minimum flow
12. Typical dimensions of karez in tunnel section
    - 12.1 Sketch of section
    - 12.2 Bed width
    - 12.3 Height to roof
    - 12.4 Depth of water
13. Material from which karez excavated
    - 13.1 Rock
    - 13.2 Conglomerate
    - 13.3 Colluvial deposits
    - 13.4 Alluvial deposits
14. Dimensions of channel as it leaves the underground section
    - 14.1 Sketch of section
    - 14.2 Bed width
    - 14.3 Height of banks
    - 14.4 Depth of water

Table 4.8 (continued) Form 2 - Detailed Data Collection for Project Implementation (Phase II)

15. Main canal to agricultural land
   - 15.1 Length of canal to irrigated area from Owkura
   - 15.2 Dimensions of canal
     - 15.2.1 Sketch of section
     - 15.2.2 Bed width
     - 15.2.3 Height of banks
     - 15.2.4 Depth of water
     - 15.2.5 Side slopes of banks
   - 15.3 Problems experienced in open conveyance section
     - 15.3.1 Washes to be crossed
       - (a) Width of wash
       - (b) Depth
     - 15.3.2 Damage from rivers or washes
   - 15.4 Materials from which canal excavated
     - 15.4.1 Gravel
     - 15.4.2 Silty/clay/loam
     - 15.4.3 Sandy/loam
   - 15.5 Lines or unlined

16. Distribution systems within irrigated area
   - 16.1 Sketch of system
   - 16.2 Length of main and secondary canals
   - 16.3 Dimensions of canals
     - 16.3.1 Sketch of section
     - 16.3.2 Bed width
     - 16.3.3 Height of banks
     - 16.3.4 Depth of water
     - 16.3.5 Side slopes of banks
   - 16.4 Problems experienced in system
   - 16.5 Material from which canal excavated
     - 16.5.1 Gravel
     - 16.5.2 Silty/clay/loam
     - 16.5.3 Sandy/loam
   - 16.6 Lined or unlined

Table 4.8 (continued) Form 2 - Detailed Data Collection for Project Implementation (Phase II)

17. Agriculture
  17.1 Present situation
    17.1.1 Crops grown
      (a) Planting date
      (b) Harvesting date
  17.2 Situation before the war
    17.2.1 Crops grown
      (a) Planting date
      (b) Harvesting date
    17.2.2 Area under each crop

18. Water delivery
  18.1 Number of mirabs
  18.2 Hectares irrigated in 24 hours
  18.3 Interval between irrigations (days)
  18.4 Seers of seed used by water

19. Beneficiaries
  19.1 Number
  19.2 Heads of family
  19.3 Number per family
  19.4 Village(s) that they come from
  19.5 Land Holdings
  19.6 Agreement to participate in works
    19.6.1 Form of Agreement
    19.6.2 Method of participation

20. Method of assessment of cleaning requirements

21. Maintenance arrangements
  21.1 Organisation
  21.2 Payment
  21.3 Numbers involved
  21.4 Maintenance period

22. Reasons for Project
  22.1 Type of damage
  22.2 Cause of damage
  22.3 Areas with mines
  22.4 Other

23. Labour
  23.1 Availability
    23.1.1 Source of skilled karez labour
    23.1.2 Source of unskilled labour
  23.2 Current Wage rates in area
    23.2.1 Skilled karez labour
    23.2.2 Unskilled labour

1.3. Stage I - Field Reconnaissance Surveys

This is perhaps the most important part of the work as it defines the nature of the work to be undertaken and the areas which should benefit from assistance. It is thus important for the reconnaissance missions to be undertaken by experienced Irrigation Engineers who are familiar with the Afghan conditions. Where possible they should also be accompanied by similarly experienced agriculturalists. Depending upon the area, the field reconnaissance mission should take between 5 and 10 days and be carried out in close cooperation and discussions with the local communities and shuras.

The main objectives of such missions should be

- To determine the extent to which the agriculture and the irrigation systems on which they depend, have been affected by the presence of the war and hostilities in that particular area;

- To identify the main thrust of any interventions aimed at bringing the systems back to the level that they were at before the war and to define the objectives of the proposed interventions and the detailed tasks that need to be undertaken to achieve them;

- To identify the inputs and resources required to accomplish the main objectives of the interventions;

- To define a detailed programme for the proposed assistance covering both the immediate and the longer term objectives;

- To establish the organizational arrangements that are required to successfully implement the proposed programme.

Before any mission is embarked upon, sufficient technical preparation is required to ensure that the proposals presented do not conflict with on-going programmes and that the area targeted is in fact an important agricultural area that has suffered from the effects of the war. The following should be carried out:

(i) Establish which agencies and organizations are already working in the area and their level of involvement;

(ii) Obtain maps of the area to be examined and identify the approximate boundaries of the command areas. Topographical maps at 1:100,000 scale are available for all Afghanistan and these area should be utilized as a basic planning tool if no other maps are available. These can be satisfactorily enlarged (by photocopying) to 1:50,000 scale.